WESTINGHOUSE

CONFERENCE -7

PLASTICS

"Plastics" is a term applied to any material which may be deformed and shaped under a mechanical stress without appreciable change in coherence, and which is able to retain the new resultant form.

It is true that under this definition porcelain, glass, metals, cellulose nitrate, pitches, rubber, synthetic resins, such as Bakelite, etc., might be included. Metals, glass, porcelain, and many types of rubber are not included in the following discussion.

Although the actual design of specific molded products may be of more direct interest, it is necessary that some mention be made of the materials, processes, and equipment. It is believed that the more general the knowledge of plastics manufacture, the easier will the application become. We find that many designers appear to be very much concerned with molded materials and feel that there is something extremely mysterious both in regard to the design and the manufacture.

For a convenient and somewhat logical means of classification, the types of molded materials are listed as follows:

<u>Organic and Inorganic</u>

Organic - Contain carbon in combination with hydrogen, oxygen, nitrogen, etc.
Thermoplastic
Thermosetting

<u>Thermoplastic</u>

Shellac - One of the earliest plastic materials.
Pitches - Also one of the first.
Cellulose Acetate - Cellulose Nitrate - Tenite Pyroxylin
Vinyl Resins - Vinylite
Styrol Resins - Victron - Resoglaz
Acrylic Resins - Lucite - Acryloid - Lumarith
Rubber Substitutes - Thiokol and Duprene

All are termed "molded compositions" by Westinghouse and are used for specific purposes for transparency, resistance to certain solvents or reagents, specific electrical properties, etc.

<u>Thermosetting</u>

<u>Urea or Thiourea Resins</u> - Beetle, Plaskon, Unyte. Useful for excellent colors, translucency, good mechanical strength. Thiourea most moisture resistant--all imported.
<u>Phenol Formaldehyde</u> - Bakelite, Durite, Durez, Indur. Countless trade names, such as Moldarta.
"<u>Moldarta</u>" is a Westinghouse trade name of the molded thermosetting resin materials with or without incorporated powders, fibers, strands, cuttings, etc. as fillers. There are approximately fifty grades of Moldarta.

Phenol-Formaldehyde materials may be divided into many classifications or types such as the following:

(1) Cellulose or wood flour filler
(2) Asbestos or heat resistant (with maximum of 200°C)
  Long - Tough and strong #102 - #160
  Short - Brittle but of low cost #186
(3) Cellulose - Electrical #173, #175, and XP-13
(4) Mineral Filled Electrical - #192
(5) Medium Impact #7498 -1 -2 -3 -4(Fairly tough)
(6) High Impact #199
(7) Special for decorative purposes, etc.
  (a) Colored - #141, #142, etc.
  (b) Water resistance
  (c) Friction
  (d) Bearing

Cold Molded Compositions

Inorganic
  (1) Cement Asbestos - Heat and arc resistant
  (2) Calcium hydrosilicate Asbestos - Heat and arc resistant
Organic
  (1) Asphaltic
  (2) Phenolic

Mycale does not come under any of the types listed. Contains lead borate and powdered mica. Expensive, but excellent strong insulation.

Molding Equipment

Presses
  (1) Ordinary presses with usually two platens for so called "hand" molds.
  (2) Semi-automatic
  (3) Automatic
  (4) Extrusion or Injection

Source of pressure usually from some central hydraulic system with accumulator, same directly driven by a pump and oil system, or purely mechanical.

Maintenance important consideration. Constant wear as a result of the high pressures and frequently moving parts, such as guides, rams, and pumps.

Molds and correlation of design with the proper material determine success or failure in manufacturing.

Molds of various types:
  (1) Positive
  (2) Landed positive
  (3) Semi-positive
  (4) Filler plate
  (5) Flash
  (6) Subcavity
  (7) Injection

Single cavity and multiple cavity.

Methods of constructing tools:
(1) Machining
(2) Hand work
(3) Die-Duplicating - Gorton
(4) Hobbing
(5) Casting - Beryllium Copper only not a commercial success.

All should be hard, abrasion resistant, tough, free from progressive distortion, non-porous, suitable for high polishing.

Type of mold selected depends on the type of material to be processed, the number of cavities required, press equipment available, the production requirements, and the nature of the part to be produced.

Finishing - Punching, Filing, Drilling, Tapping, Buffing.

Plastic materials serve for structural, insulating, and special purposes. Strength, appearance, weight, low cost, freedom from deterioration, permanence, and other properties are possible advantages of molded materials.

Usually a design is conceived and, after the necessary mechanical devices are perfected, the question of insulation arises. It is obvious that in a compact unit, such as a circuit breaker, the main body and supporting members must be of an insulating material. No other insulation will serve as satisfactorily as a molded product. On the other hand a switch or contactor may require insulation without such exacting requirements for dimension tolerances, appearance, or impact resistance. In this case, consideration must be given to other forms of insulation as well as to plastics.

For the proper selection of the best type of Moldarta or Molded Composition, it is essential that all factors be considered on the following basis:
(1) Location of apparatus - Inside or outside - Protected or unprotected.
(2) Probable conditions if inside - Dirt accumulation - Humidities.
(3) Type of insulation - Voltage - power factor - insulation resistance.
(4) Arc resistance
(5) Type of applied stress - Tensile, flexurol, compression, shear, or torsion.
(6) Maximum temperatures.
(7) Methods of assembly
(8) Costs

There are many suggestions that we might give on the subject of preferred forms; however, such details are recognized more easily after the designer understands the technique of molding. The application of reasonable thought should enable him to:
(1) Avoid undercuts.
(2) Incorporate fillets for strength.
(3) Provide adequate wall or material between holes.
(4) Not to attempt molding in very delicate pins particularly horizontally without a support.

(5) Avoid indentations at points of maximum stress.
(6) Permit incorporation of considerable taper on inside of walls with a minimum of one half of 1°. If possible use 1°.
(7) Allow liberal tolerances and
(8) In questionable or complicated designs or for improvements in appearances there are many advantages to be gained by preparing a model of hard rubber, an easily machined plastic, or wood.
(9) Determine the proper material before the expensive tools are provided.
(10) Use standard inserts if possible.
(11) Use raised letters or figures except for parts requiring hobbed molds.
(12) Use straight wall holes and self tapping screws or rivets for economical assemblies.
(13) Although there is no fixed rule - Limit in most cases the length of an insert to 2-1/2 times the diameter.
(14) Holes of any appreciable depth frequently should be designed with a larger diameter for the greater part of the depth.

For Cold Molding the designs must be relatively simple as the material is merely without mechanical strength. The molding of the inorganic cold molded materials is much more difficult than that of the hot molded materials, for it is necessary that the materials be permitted to expand with a minimum of pressure against the mold walls or depressions.

For the most successful results consult with the representatives of the molding department frequently, both on material selection and design.

REFERENCES

1. "The Chemistry of Synthetic Resins" by Carleton Ellis
   Very complete but deals more as indicated with the chemistry rather than the application of resins.

2. "Plastics and Molded Electrical Insulation" by E. Hemming
   Rather old reference, but a very good reference for anyone wishing to obtain general information.

3. "Plastic Molding" by L. F. Rahon
   Contains but little on materials but covers the equipment and molds to a greater extent than some of the other books.

4. "Modern Plastics" Issued monthly.

   "British Plastics" Issued monthly.

5. "Modern Plastics" Catalogue and Directory
   October 1936 and October 1937

6. Standard Sheets

CONFERENCE 71

INDUSTRIAL RELATIONS

(1) What is the function of an Industrial Relations Department?

The coordination of human relations with a view of getting maximum production with the minimum of effort and friction, with proper regards for the genuine well being of the workers, is the task of the Industrial Relations Department. Such an activity is known as industrial relations. The genuine well being of the workers must be the aim at all times, and it applies equally well to the entire group as to the individual. Friction is bound to occur even when the efforts are for the well being of all.

(2) What is it that causes this friction in industry?

The main causes are the clashing of personalities and the defeats of individuals and every one has his own physical and mental characteristics. Our physical characteristics are visible and our physical actions can be observed. Our mental processes, however, go on unnoticed and we know what they are by an interpretation of resulting actions and attitudes. We employ brawn, brain, heart and disposition--all sorts of elements that make for a personality. Every action of an individual is motivated by some urge, and the manner in which the individual meets the difficulties encountered in his attempts to reach his objective determines his general stability. These urges or stimulations in individuals may be over-stimulated or repressed by some thoughtless individual, and a behavior results that seems extremely strange. The behavior of persons which result from mental processes is what we are primarily interested in. Some knowledge of the laws of individual behavior and the conditions which affect them is necessary to understand mental processes. We understand in part, but many times we are so engrossed in the physical that we overlook and forget the mental processes of the individuals with whom we deal and thereby lose an opportunity. We are often baffled, but we should not be for there is a reason for everything, especially behavior, and if we knew the past history the answer to many situations would be obvious. Most industrial relations problems, I am confident, are the results of something that has happened in the past. We are reaping what others have sown and we are sowing for others to reap.

(3) What is being done to keep these frictions to a minimum?

(a) Centralized Employment

A centralized employment department makes for a better selection of applicants to fill requisitions for help. A better picture of the entire labor situation is provided. The personnel of the employment department has an opportunity to study the employes and to know them in a different way than the manufacturing supervisor. It provides an opportunity to make use of a transfer system that relieves tensions and gets the workers better fitted into industry. A better understanding of the needs of industry is secured and therefore training programs can be carried on in a more intelligent manner. A centralized employment department will be of greater value in the future as the labor problems become more complicated.

(b) Job Classification

The classification of jobs has done much to relieve friction among employes. The job is classified and not the employe on the job. If the classification job has been done in an honest manner, and the employe believes in it, it tends to make for better understanding as it tends to overcome the thoughts of unfair treatment.

(c) Rates of Pay

An established key sheet with definite limits based on classification does much to clear away suspicion and criticism. Incentive systems may vary to such an extent that conditions may exist that will cause dissatisfaction, but such cases are not the result of the key sheet or classification, but rather the administration of the incentive system.

(d) Safety and Health

Employes like to work in a safe plant, and if they realize that an interest is taken in safety work, employes will be more contented, and this will eliminate a cause of worry, and worry always results in bad attitudes. Health is very closely allied to safety, and, if a factory is properly ventilated and heated and fumes taken care of by proper ventilation systems, men work better and are happier.

(e) Handling of Employe Problems

1. Worker and his work.

A worker may be fully qualified and have sufficient intelligence to perform his work and may be doing a fairly good job, but there may be something about the job that is making the employe unhappy and dissatisfied with his work. We endeavor to determine these facts by whatever means available and clear up the situation or, by the use of our transfer system, secure a job more to the liking of the employe. If we fail, it is because we don't know and don't even suspect.

2. Workers and Fellow Workers.

Workers are social beings and most of the worker's social contacts are at the work bench. It has been said that social contentment is more valuable than money. In former days when employes did not make social adjustments they moved on to other employment. Today they remain and make their discontent known in other ways. If social contentment does not exist, demands may be made to compensate for what they are missing. The Company has provided an opportunity for the employes or organize a sick benefit association, provided free insurance, made a set-up for contributory insurance, and made provisions for old age incomes. All are for the purpose of better social contentment. All activities among our employes in the way of athletic programs, social events and special programs have for their aim this satisfaction of the employe's social nature.

3. Worker and his Immediate Supervisor

The immediate supervisor to the worker is management and this places a great responsibility on all supervisors. If a feeling does exist between the worker and his supervisor it is due to misunderstanding brought about largely by different personalities. The supervisor realizes that we are going to have labor representation of some kind and that he is wasting time if he complains of the conditions as they exist. The supervisor of today knows that if he hopes to succeed he must conduct himself in such a manner as to get the respect of his men regardless of any employe representation plan. The training they receive is to look at the worker's problems in the light of it being their own problem and that action taken must be for the genuine well being of the employe.

4. Worker and his Individual Problems

Many workers have individual problems of a trying nature and it is the task of management to be as helpful as possible in these cases. Our employe service activity does many things to lighten these individual burdens even if it is only in making the individual understand that we appreciate his problem and are sympathetic. Fear grips many employes and makes for discontent. We endeavor as far as possible to secure frank discussion of problems to clear away doubt and uncertaintity.

5. Workers and Management

Most of the worker-management problems and the antagonistic attitude of workers to management are due to lack of understanding or the attitude of personalities who by their mental processes have become maladjusted. The problem is a hard one to solve as it is difficult to present management's view in a satisfactory manner to convince the employe that the policy is for his genuine well being. All forms of employe representation are based on the theory of a better understanding brought about by a frank discussion of the problem.

The National Labor Relations Act has as its purpose the forcing upon reluctant employers, employe representation. In the beginning of the Act it states that the denial by employers of the right of employes to organize and the refusal of employers to accept the procedure of collective bargaining leads to industrial strife or unrest. It is hereby declared to be the policy of the United States to mitigate and eliminate these conditions when they occur by encouraging the practice and procedure of collective bargaining.

Westinghouse has been a leader in the study of better relationships between workers and management. It was to improve relations that our Employe Representation Plan was originally worked out. Our wage adjustment payment plan was worked out to improve the relationship between employes and management.

The Labor Relations Act has changed our manner of employe representation and our actions are governed by the provisions of the Act. The policy of the Company is unchanged.

Questions

73

CONFERENCE

WASTE ELIMINATION

For an understanding of the problems of waste in industry and its elimination, we may consider the following points especially applicable to draftsmen:

1. Failure to use standard materials and parts, and development of special units instead.
2. Failure to design around available tools and equipment.
3. Failure to specify on drawings the numbers of the tools to be used.
4. Spending, or using extravagently, carelessly, or unproductively.
5. Idle time, material, machinery, equipment, etc.
6. Unsalable or useless products of a manufacturing operation or process - residues.
7. Loss caused by errors.
8. Loss caused by accidents.
9. Inefficiency.

The Federated American Engineering Societies conclude that the chief burden of responsibility for waste in industry falls on management, assigning 81% as being due to faulty management. As used here, the word management embraces Salesmen, Designers, and Draughtsmen, as well as Administrators, Executives, Managers and Supervisors.

Stuart Chase in "The Tragedy of Waste" lists "Faulty design control - lack of standardization of equipment and products" as the second greatest source of technical waste.

Mr. W. A. Durgin, late Chief of Division of Simplified Practice in the Department of Commerce has estimated that $10,000,000,000 a year could be saved in the United States through industrial simplification. The waste that he warns against comes entirely from over-diversification.

You are familiar to some extent with the manufacturing processes involving tools, fixtures, machinery, equipment, patterns, etc. and it is unnecessary to describe them to you. You know also that a very large amount of our Company's business is in standardized products whose activity is sufficient to justify manufacturing in large quantities. It is necessary to keep in mind the advantages derived from standardization, which enables manufacturers to do machining and other operations more or less continuously, that is, without having to frequently set-up tools and equipment for handling different kinds and sizes. The cost of setting-up tools and equipment is a major item in the total manufacturing cost.

Standard materials and parts must always be used unless there is nothing available to meet the requirements. Special parts and assemblies cost more than standards, more time is required to produce them, they break up the continuity of straight line production, and when for any reason they cannot be used, they must be scrapped. Notwithstanding the ever increasing trend toward greater technological obsolescence, if products are made of <u>standard materials</u> in <u>standardized sizes</u> their eventual salability is good. Even if future sale is entirely precluded, their salvage value is increased greatly by the fact that the component parts are useable. A finished product consisting of an assembly of standard parts can be dismantled, and the parts turned into stock with a saving, but an assembly of special parts when dismantled brings only the scrap value of the metals, minus the cost of dismantling and separating the different kinds of metal.

It is exceedingly important to design pieces or parts and assemblies in such manner as to permit the use of available tools and fixtures. The cost of tools and fixtures is a considerable part of the total manufacturing cost, and there are two principal reasons for providing them. First, to secure precision in machining and assembling, and, second, to facilitate the various manufacturing operations. The use of tools, jigs, and fixtures makes it possible to supply parts which fit accurately, whereas if it were necessary to lay out the work by hand, there would not be the same precision, and there would be considerable adjusting necessary when fitting or assembling the parts. This is particularly important when replacing worn parts with new ones in the field.

The extent to which tools, jigs, and fixtures are provided is determined largely by the activity of the product, but there are some products which cannot be made without tools. A good example of the latter is sheet steel laminations for rotating machines, many of which are required for one motor or generator. For single machines or those which are seldom ordered, the laminations are stamped out with separate blanking and slot dies, but where there is sufficient activity to spread the cost over a large number of pieces, compound dies are provided. Similarly, the anticipated activity of castings determines whether to make inexpensive wood patterns or more costly metal patterns.

Many pieces, formerly cast and involving expensive patterns, core boxes, etc. can now be constructed by welding, and their cost is considerably reduced. When patterns and core boxes are available, they should ordinarily be used, but the relative cost of castings and welding should always be considered. The cost of storing patterns and tools is a large item, as the manufacturer may be required to furnish renewal parts long after the apparatus has been shipped. Also, as in the case of large installations of industrial and railway motors, we must be prepared to furnish additional units on short notice when a customer wishes to purchase identical apparatus for extending his operations. This is particularly important to the customer, because, when he is able to obtain identical apparatus, his renewal parts problem is simplified.

Tool records are provided for the use of all drafting departments, and one of the most important things for the new draftsman is to learn how to use them. No new or changed drawing should leave the drafting office without assurance that all available tools required for production are specified. When a new drawing includes a piece or part which has already been made on another drawing, the tool numbers appearing on the old drawing should be specified on the new one. If the piece or part is changed in any way, and there is doubt that the tools will be suitable, the old drawing **number** should be specified as a tool reference on the new drawing.

Obviously, the most economical material always should be selected, but, it must be in keeping with the high standards of our Company. There are numerous kinds of steel, brass, and other materials at varying costs. Material costing only a fraction of a cent per pound more than another suitable grade may increase the apparatus cost considerably, and when the product is particularly active, the excess cost over a period of time may amount to a large sum. The high standard of Westinghouse Quality always must be maintained, and it must be done in the most economical manner; in other words, the material we use must be equal to or better than our competitor's, but we cannot be extravagant, and our costs must be as low as our competitor's or lower. The word extravagant as used here means--exceeding reasonable limits, excessive, and wasteful.

Idle time, material, machinery, tools and equipment, increase the cost of production, and effect adversely every member of the industry. This is particularly true as regards idle time in an industry like ours where wages and salaries are a large proportion of every dollar in factory cost. Idle material, machinery, tools and equipment, cost just as much as if they were in use every day, and this is a sizeable part of the total factory cost. If these wastes are excessive, they can force selling prices up to a height where they are not competitive, and a manufacturer may lose his business.

The unsalable or useless products of a manufacturing operation or process, are the short ends, trim, and residues. The short ends and trim materials come from bars, rods, sheets, and strips, and the residue is dross from the processing of metals. Bars, rods, sheets and strips of metal, and insulating and spacing materials, are purchased in standard commercial sizes, and there is, generally, a short length or side pieces left after cutting off or stamping out the maximum number of pieces to be had. For example, if a multiple of pieces two feet long is cut from a mill length of seventeen feet, there will be eight pieces and a short end approximately one foot long left over. Further, if 28" diameter laminations are stamped out of 36" wide sheet steel, there will be left over 8" in width, in addition to the end piece.

Only approximately 50% of the electrical steel purchased by our Company goes into finished products; the balance in the form of trim, ends, and centers, is scrapped. Under what might be called normal business conditions we use per month at East Pittsburgh one and one-half million pounds of low silicon electric sheet steel which costs us four cents per pound. Of this quantity we scrap approximately one-half and obtain for the scrap only one-half cent per pound. The total cost of the portion scrapped, namely 750,00 pounds, is $30,000 and obtain for it only $3,750.00 - a loss of $26,250. A similar situation exists on steel plates, of which we purchase a very large amount. Every effort must be made to utilize a greater proportion of these materials, and the draftsmen can help.

Errors in drawings are responsible for a considerable amount of waste in industry, and every effort must be made to avoid them. These are particularly bad when not discovered until the piece or part has been assembled with other pieces, and it becomes necessary to dismantle, supply the correct piece, and re-assemble. The cost of correcting the drawing is only a part of the total cost, and often it is a very small part.

It is very important that all dimensions required by the shop be specified on the drawing. The workmen should not be expected to do any calculating to find dimensions to which they must work. All information on the drawing should be specific, and nothing should be left to the judgment of the individual who will do the machining, assembling, or other operation.

A considerable part of the waste bill comes from accidents, and the draftsmen can do much to help prevent these. Our products must be as safe as the best engineering, materials and workmanship can make them, both for those who do the manufacturing and for those who use the products. A few examples of this are:

1. Man-holes or doors of proper size should be provided for boilers, tanks, etc. which have to be entered to make repairs, or for cleaning.
2. Guards should be provided for machines and equipment when they are designed, rather than leave this for attention after installation of the machines or equipment.
3. Particular attention should be given to dust and fume hazards. In some cases ventilation systems may be necessary, with alarms to give warning when dangerous atmospheres are present - either from an explosive or toxic standpoint.

Quoting from M. C. B. Auel, a former official of our Company, now deceased, "The word 'efficiency" is but another, though less harsh way, of speaking of waste; for instance, 25% efficiency means 75% waste, and 75% efficiency is 25% waste. There is in fact but one point in this entire scale from 0 to 100 where no waste is involved and this is at 100% efficiency."

Let me give you an outstanding example of inefficiency. The steam boiler, the steam engine or turbine and the electrical generator have been so perfected that we feel there can be little more done to improve them. Every lump of coal has energy locked within it that needs only releasing, as when burned under a boiler, to do useful work. Assume a piece of coal is to be fed piece-meal into a furnace. By the time it is all gone, this is what has happened:
1% of it has fallen through the grate unburned and all of its energy has been lost.
2% has been incompletely burned and most of its energy has been lost.
The heat or energy from another 24-1/2% has escaped up the flue or has been radiated away or has leaked out of boiler and piping.
54% is wasted due to the energy in the steam not being completely extracted as it passes through and drives the engine or turbine.
3-1/2% goes into miscellaneous losses.
This leaves only 15% delivered by the generator at the switchboard of the power and light station ready for use.
Transmitting and distributing this from the switchboard out over the country to consumers entails a loss of 2% in cables, transformers and wiring in buildings, so that when ready to enter electric lamps, there is only 13% left.
About 90 to 95% of the energy entering the electric lamp is expended in heating the filament before the light is seen, leaving only 1% to 1-1/2% of all the energy originally in the block of coal for the actual light.
When it comes to inefficiency you will agree that this is an almost perfect performance.

Compare this with one of natures - the light of the fire-fly. Scientists tell us that only the female is able to make the light and it is given them so they may be located by the males, but you and I know it is really given to enable them to hunt the males, who have a habit of staying out late. Their light is the cold light which scientists have been trying to duplicate, practically none being lost in heat.

Truly, anything short of 100% efficiency is waste, but much of this waste is unavoidable. There is a continuous effort to increase efficiencies and much progress is being made; however the illustration of our inefficient utilization of the energy in coal shows that we are still extremely wasteful. The first step in our waste elimination program is to arouse a consciousness of waste in all its forms and the second step, which is everlasting, is to be thrifty in all that we do. This word THRIFT means economy and economical management of our resources.

Our Nation has a reputation for wastefulness, and, in truth, we have earned it by our disregard for conservation and frugality. We see this in the depletion of our timber in certain parts of the country, and in the almost complete elimination of the buffalo. The same thing is happening in the oil industry and elsewhere. If we are to prosper as an industry, which cannot be without national prosperity, we must learn the full meaning of the work THRIFT, and must be mindful of it always.

Quoting from <u>Melincourt</u> - by T. L. Peacock - Chapter 24....

"The Waste of Plenty is the Resource of Scarcity".

From the Crust of Bread - Author unkonwn......

"For Wilful Waste Makes Woeful Want,
and I May Live to Say
Oh! how I wish I had the Bread
That Once I Threw Away."

From Shaeksepare's Twelfth Night.....

"The Clock Upbraids Me With the Waste of Time."

At Westinghouse, we have additional incentives for thrift, the principle one being our Wage and Salary Adjusted Compensation Plan. You are familiar with this plan, having felt its benefits in your pay envelopes for some time, therefore, I need not explain it to you. The amount of adjusted compensation in your pay envelopes depends a great deal upon the extent to which you practice thrift.

Another incentive is the Suggestion System, by which employes are rewarded for suggestions that help maintain and improve the quality of our products and lower their costs. Last year a total of $18,685 was awarded by our Company, and this year the total probably will be greater.

Questions

CONFERENCE 74

CONSERVATION

You should now have a good idea of the Westinghouse organization; the thought and planning necessary to design and sell apparatus, the facilities for manufacturing, the planning necessary for economical production, and the control of material and standard parts.

Despite all functions that have been set up for economy control, we still do not use material or our time, nor perform our planning, for the greatest economic good.

(1) Example: - One error on a drawing causes:
- (a) Stoppage of work - workman and company suffer.
- (b) Loss of supervisor's time in checking in shop, and consulting with drafting department.
- (c) Loss of draftsman's time in checking shop request.
- (d) Additional expense of changing tracing, providing new prints, new manufacturing information, etc.

During all this time the job and the machine tool are held up.

(2) Examples of recent uneconomical practice.

(3) Materials - $75,000,000 worth purchased in 1937. Consider the following:

(a)

Material	Average Cost - New	Average Salvage Cost
Copper	.20	.094
Brass	.17	.062
Steel	.045	.004
Aluminum Sheet	.38	.167
Monel	.49	.049

- (b) Evil of designing first and then trying to find material.
- (c) What is involved when small amounts of special sizes are specified on drawings.
- (d) Necessity of using standard parts.
- (e) Salvage system.

(4) Economy of using tools:
- (a) Shop does not know of tools unless specified on drawing.
- (b) Tool investment, which must be recovered.

(5) Planning drawings:
- (a) Use of tabular drawings

(6) Preferred number series - reason and application

(7) Necessity of continually consulting Standards Books

(8) Realization that every piece of material, each part, and every machine represents money; as does also the time of each person in the plant.

Questions

CONFERENCE 75

THE CENTRAL ENGINEERING LABORATORIES

The Central Engineering Laboratories comprise a group of facilities for use in test and experimentation on Westinghouse equipment. The laboratories are the proving ground for the equipment designed by the engineers and draftsmen and built by the shop.

The Central Engineering Laboratories are comprised of the following groups:

Laboratory	Test Function
Impulse - 5-L-21	Surge tests on arresters, De-Ion tubes, breakers and transmission line apparatus.
Engineering - 5-L-33	Individual or component parts of design, such as air cleaners, molded materials, coils, etc.
Radio Interference - 5-L-38	Measurement of Radio Interference voltage on appliances and transmission apparatus - carrier current and choke coils.
Railway - 2-L	Railway motors and control. Heat runs and performance tests.
Rectifier - 2-L	Mercury arc rectifiers, ignitrons and other rectifying devices.
Direct Current - 2-L	D-c breakers, contactors and d-c control equipment.
High Power (Station 1 (Station 2	Breaker Performance tests, reactors, breaker development.
High Voltage - Trafford	Surge and 60 cycle tests on line insulation, breakers, transmission line and substation equipment.

Each laboratory has its particular function to perform in routine testing, but improvements are continually being added to further increase the laboratory's utility. These additions often require considerable fundamental study which is carried on as pure development. The laboratory engineer is a proof-reader for the draftsman and engineer. The tests, made by the laboratory engineer, must be reliable, whether they agree with the design or not. Very often laboratory tests show up the fundamental errors in design which would otherwise not be apparent until the product reached the field. Then it is costly to re-design the apparatus and is attended with loss of company prestige.

The advertising value of the laboratory is a distinct company asset as it enables the sales department to sell proof-tested designs which give customer satisfaction and promote goodwill. The honest design sells the equipment or apparatus, and the quality of material and design keeps it sold. Westinghouse may well be proud of its proof-tested designs. Our success in the Electrical Industry has been earned by Honest Design, Honest Tests and High Quality.

Questions

CONFERENCE 76

DESIGN FOR APPEARANCE

Elements of Visual Perception (Visual Perception is immediate fundamental knowledge as sensed through sight).

(1) Line
(2) Area
(3) Value (Intensity of Depth, etc.)
(4) Color
(5) Volume (Measure of space)
(6) Space (Distance between objects)
(7) Texture (Picture as a whole unit)

Arrangement of elements can be such as to create any desired reaction of force, movement, control, general balance, etc. (Example, Skippy cartoon)

Desire for association and ownership may be created by appearance. (Example, Pretty girl cigarette advertising)

Consider appearance factor in nature, men, women, animals, trees, flowers, water, and mountains. Importance of appearance.

Appearance factor in apparatus design.
Example - Domestic appliances
Machine tools
Control apparatus
Railway locomotives - cab location
Switchboard panels
Meters, etc.

Controlling factors of appearance in actual apparatus design:

(1) Life
(2) Function
(3) Space factor
(4) Materials
(5) Time available
(6) Activity
(7) Manufacturing facilities

Industrial designer and machine designer must co-operate, but specialization is necessary.

In all design work, the designer must be appearance conscious.

<u>References</u>

"Industrial Design Comes of Age"
<u>Business Week</u>, May 23 - 30, 1936

"Is Appearance Design an Engineering Function" by H. R. Trotter, Hacker Manufacturing Company
<u>Electrical Manufacturing</u>, March, 1937

Questions

CONFERENCE 77

SALES DEPARTMENT

The organization of the Sales Department

The headquarters Sales organization

The District Office organization

The Merchandising Sales Department

The Westinghouse Electric Supply Company

The Westinghouse Electric International Company

Scope and variety of products sold

The volume of business

Value of sales

Variety of customers

Competition

Credit

Collection

Warehousing

Questions

CONFERENCE 78

MAINTENANCE AND RENEWAL PARTS

National Scope of Annual Maintenance and Renewal Parts. Value $5,250,000,000.

Employs - 6,500,000 to 7,000,000 men.

Electrical Apparatus - Annual Maintenance - Nationally $1,250,000,000.

Westinghouse equipment, approximately $35,000,000 to $40,000,000.

Renewal Parts and Maintenance business in periods of depression and prosperity.

Westinghouse Organization and facilities for handling:

- 34 Service Shops
- Headquarters Service Organization
- Headquarters Renewal Parts Organization - Organization in each Works
- Emergency order set-up in each Works Production Department
- Headquarters Renewal Parts Group, which functions in each Sales and Manufacturing Division

PL-120 Price Form - approximately 80,000 style numbers.

Prices and discounts - approximate cost of printing, $15,000.

Renewal Parts data showing description of all parts, apparatus using same, and number of each piece required - furnished to all customers.

Approximate number of Westinghouse customers.

Homewood Works - why it was built and its outstanding feature in the electrical industry.

Monument to George Westinghouse.

Company's Engineering -

Using standard parts of previous designs, bearing in mind the continual replacement of wearing parts for easy accessibility and interchangeability.

Rehabilitating our designs, such as Transformers at the present time.
PL-150 Sharon Works.

Outstanding job along this line - P. R. R. Locomotives P5-A, GG-1.

Other outstanding jobs are Meter and Instrument set-up, No-Fuse Load Center, Standard Control Apparatus, Standard part for panels and switchboards, etc.

CS Standard NEMA Motor.

Machine Tool applications

Standardization of Carbon Brushes and Carbon Boxes.

NEMA - Standardized Parts Committee recently appointed by the Chairman of the Renewal Parts Group.

Standardization of disposition of jigs, tools, fixtures and patterns.

Questions

CONFERENCE 11

D. C. MACHINES

1. Organization set-up in Generator Division
    (a) Group Leaders
    (b) Detailers - Checking, etc.
    (c) Speed vs. Accuracy

2. Drafting Standards - Appearance - Arrangement
    (a) Unit Specifications
        (1) Advantages - Uniformity
    (b) Master Drawings
        (1) Office - Time Saving
        (2) " Expense "
        (3) " Uniformity
        (4) Shop - Time Saving
        (5) " Cost "
        (6) " Cost Line Up - Maching - Welding - Assembling
        (7) " Familiarity with Standard Drawings and Arrangement
            a. Time and money saver and few errors

3. D.C. Machines and Rotary Convertors
    (a) Rotors
        (1) Shafts
        (2) Spiders (Welded vs. Cast)
        (3) Commutator Bars
        (4) Armature Coils
        (5) Armature Punchings
        (6) Complete Rotor - Treatment, Finishes, Notes
    (b) Stators
        (1) Frames
        (2) Poles
        (3) Coils
        (4) Brush Rigging

4. Data on why and how we make, finish, or treat various parts of our apparatus, from engineering and shop viewpoints.

5. Special or unusual apparatus or application.

Questions

CONFERENCE 80

A. C. GENERATORS

1. Description of a generator
   (a) Salient pole generators
      (1) Horizontal
      (2) Vertical
      (3) Types of drive
   (b) Turbine generator

2. Turbine Generator
   (a) Hydrogen-cooled type
      (1) Description of various parts
      (2) Advantages of hydrogen cooling
   (b) Air-cooled type

3. General discussion
   (a) Shipping limitations
   (b) Various sizes of machines built and their location

4. Discussion of materials used

Quesions

CONFERENCE 81

SWITCHBOARDS

Use of Switchboards:

Control and distribution of power from central points.
Generating plants, measuring, limiting, etc.
Prime movers - steam, water, diesel and other motors, A.C., D.C.
Switchboards, assemblies of devices and apparatus made by other departments or companies.

First Switchboards:

Wood with marble or other dielectric bases for switches, etc.

Next:

Marble panels, soapstone, slate, other high-grade stones.
Asbestos - some of these are still used.

Now:

Modern switchboards of steel with insulated devices
Panels fixed in straight or circular line
Panels in line, swinging.
Panels back to back, fixed or swinging
Control desks, straight, circular, convenience, mimic bus.

Power Distribution and Control:

Old style switchboards with equipment direct operated usually from board
- (1) With equipment direct mounted
- (2) With equipment remote

Later - Limitations of above led to electrically operated equipment-breakers - switches, etc. Usually remote in a separate structure (another room, another floor, other building) operated electrically by small switch. Lamp indication (from main device - not from small switch) Operation indication.

Automatic equipment - unattended. The requirements operate the devices.

Supervisory

Structures of breakers, transformers, disconnecting switches, connection and main buses, lightning arresters, power transformers.

- Indoor structures
  - Pipe frame
  - Masonry enclosed
  - Open frame structural steel
- Safety type, metal enclosed
  - Metal clad, lift-up
  - Trucks, draw-out
  - Cubicles
  - Oil or compound filled
  - Bus compartments
- Outdoor structures
  - Pipe frame
  - Open frame - structural steel, steel towers on power line
  - Steel enclosed, switchhouses, oil filled.
- Regulators
  - Resistors and their control
  - Current - Voltage

SWITCHBOARDS (cont'd.)

Other devices used - principally obtained from other departments or divisions:

- Circuit Breakers
- Air break - "CL" - "HS" - "AB" De-Ion
- Oil - sizes - current - voltage - kv-a - De-Ion Grids
  - Main contacts - arcing tips
  - Treatment and finish of contacts
  - Surface area vs. pressure
  - Silver
- Switches
  - Disconnect, knife
  - Control - Instrument
  - Push Button
  - Auxiliary for indication - Sequential operation
  - Push Button for indication - reset - ground detector lamps - tripping
- Instruments
  - Indicating valve of current - voltage, etc.
- Meters
  - Indicating or recording current - voltage, etc.
- Relays - for three uses; Service protection, Equipment protection,
  - Automatic control - Silent Sentinels
  - 1st fuse, overload, underload, overvoltage, undervoltage, overcurrent, reverse current, timing, differential - unbalance, directional, phase balance - protect against unbalanced and single phase operation - reverse phase, thermal, overspeed, auxiliary
- Test Switches
- Indicating lamps

General

- Finishes, wiring, latches, hinges, welding - rods and coatings
- Brazing - silver solder, phos-copper alloy - temperature
  - New methods of attaching silver to copper
- Materials
  - Steel - ordinary, hot-rolled, cold-rolled, surface finish - punching - shear-drill - stainless, non-magnetic, alloy steels for deep drawing, rust resisting, etc.
  - Copper and alloys - brass - Everdur - phosphor bronze
    - Resistance of alloys
    - Hardness due to cold working and its loss
  - Aluminum and alloys - anodizing - welding
  - Silver for contacts
  - Hardware - why cadmium plate - galvanic action (why aluminum and copper bad)
  - Micarta - sheet and tube
  - Plastics - cold flow

Education and Training required by draftsmen for success in switchboard work.

Photographs of interesting boards and applications

Questions

CONFERENCE 82

CIRCUIT BREAKERS

1. Oil Circuit Breakers
    a. What They Are
    b. How They Function
    c. Their Application to Various Circuits
    d. Various Types
        1. Indoor
        2. Outdorr
        3. One, two and three poles
        4. Plain break
        5. De-ion Contacts
        6. De-ion Interruptors
    e. Design
        1. The use of standard materials
        2. The use of copper for conductors
        3. The use of silver for contacts
            (a) Travel, break and speed of opening
        4. The use of oil
            (a) Temperature rise
        5. Insulation, creepage, and striking distance
    f. Solenoid Closing Mechanism
        1. Necessary Force to close the breaker
        2. Tripping Mechanism and trip free protection
        3. Standard 600 ampere, 15000 volt Solenoid operated breaker used to demonstrate
            (a) Closing
            (b) Opening
            (c) Construction

2. Education
    a. Necessity of proper technical training
    b. Where best obtained

Questions

CONFERENCE 83

SWITCHGEAR APPARATUS

Switchgear Apparatus

1. Knife and Disconnecting Switches
2. Fuses
3. Choke-coils
4. Capacitors
5. Air Break Circuit Breakers
6. Net-work protectors

Suggestions to Junior Draftsmen:

1. Selection of drawing paper most suitable to job.
2. Size of paper large enough to allow for additions.
3. Allow plenty of space below bill of material.
4. Detail views to agree with those on assembly. In specific cases locate to minimize shop layout work.
5. Practice constructive criticism of layout and old reference drawings.
6. Symmetric views - Show only half but provide space for eventual addition of other half.
7. Dimensions - Samples - Tie together parts that work together. Special attention to limits.
8. Bill of Material
   a. -----, from -----
   b. -----, burn -----
   c. (----- Required - 1
      (make 3 from -----
   d. Study variations in Standards Book
9. Changes (G-letters) - Check original layout man and engineer who wrote letter.
10. Make subnotes easy to understand.
11. If a detail is changed from one medium to another (Say C.R.S. to forging - or casting - or permanent mould) it should be redesigned to suit the new medium.
12. Increasing importance of cost - design for minimum operations - avoid all possible operations to make an item.
13. Avoid countersink head screws if more than one.
14. Allow plenty of clearance for bolt holes, if more than one.
15. Dimension to guide tool designer, to make him locate from the important point; often this will eliminate one machining operation.
16. Cost of errors - example:
    a. Term. block 85-B-340 $2800 Dis-assemble and provide more room for wiring, and re-assemble
    b. Multiplier
17. Know your shop.

Questions

CONFERENCE # 4

TRANSFORMERS

D.C. System Vs. A.C. System

The present A.C. System made possible by the transformer

Principles of operation

Construction:

a. Winding. Current circuit - Copper
b. Core. Magnetic " - Iron. Core & Shell Types
c. Insulation. Solid - Liquid. Bushings
d. Tank - Radiators, etc.

Classification:

a. Power - Transmission. Large capacity. High voltage
b. Distribution. Medium - small " Intermediate voltage.
c. Instrument. Current - Potential. Low VA rating.
d. Auto, Motor starting, etc.
e. Street Lighting. Constant current.

Cooling Methods:

a. Self-cooled - Dry type.
b. Air blast
c. Oil insulated - self-cooled.
d. Oil insulated - water-cooled.

Rating	KV-A - KW, Power factor. Voltage. Current.
Frequency	25, 50, and 60 cycles ($\sim$)
Phase	Single phase and three phase circuits (ϕ)
Ratio	Primary to Secondary. Parallel - Series connections. Taps.
Polarity	Additive - Subtractive.
Connections	1 ϕ - 3 ϕ , Star and Delta three ϕ connections.

Importance of proper connection, phase relationship and polarity.

Instrument transformers are used primarily to change the current or voltage in a definite ratio for use in connection with standard meters and instruments, and to isolate the operator as well as other apparatus from the high voltage circuit.

Instrument transformers are designed for small VA load but for extreme accuracy.

Questions

CONFERENCE 85

METERS AND METER CONNECTIONS

Purpose

Indicate and record the performance of electrical machines.

Types - Portable - Switchboard

Indicating - Integrating - Recording

Ammeter
Voltmeter
Wattmeter
Temperature meter
Tachometer
Use of shunts

D. C.

Ammeter
Voltmeter
Wattmeter
Temperature meter
Tachometer
Frequency meter
Reactive KVA meter
Time error meter
Power Factor meter

A.C. Single Phase
Polyphase

Use of Instrument Transformers

Telemetering

Diagrams

1. Show simple circuits without shunts or instrument transformers.
2. Develop and show shunts and instrument transformers.

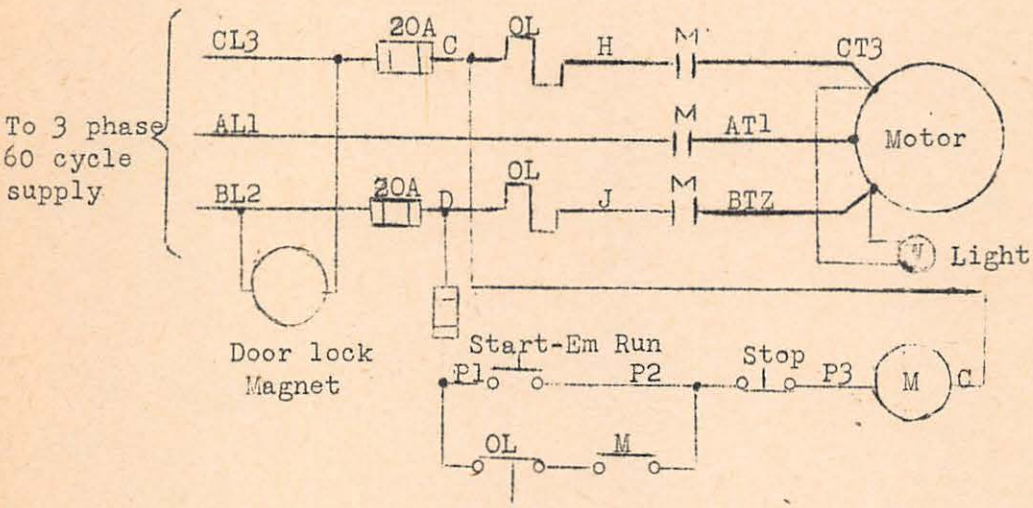
Questions

CONFERENCE 8b

CONTROL

Discussion of an elementary control circuit

Elementary controller diagram



Description of Operation:

To start the motor, the operator must depress the "START-EM. RUN" button of the push button station. This will energize the coil of the line contactor #M through the closed contacts of the stop push button. #M coil closes three #M contacts and the motor will start. An interlock contact of the line contactor will close and bridge the start button through the O.L. relay keeping the line contactor energized and the motor connected to the line, after the push button has been released. When contactor #M closes, a white signal light connected to the motor terminals will indicate that the motor is running.

The motor will stop if the "STOP" button is depressed or the overload relay trips, thus interrupting the coil circuit on contactor #M. In the latter case the O.L. relay must be reset by pulling a reset button on the side of the cabinet before restarting the motor. In an emergency the motor can, however, be started without resetting the relay by pressing the "START-EM. RUN" button. The contacts of which by pass the O.L. relay. The motor will in this case run only as long as the button is held closed.

A magnetic door lock is provided, which locks the enclosure door, whenever the controller is energized. To gain access to the inside of the cabinet, it will be necessary to open the disconnect switch at the main distribution board, thereby de-energizing the door lock coil.

Questions

CONFERENCE 87

CONTROL

1. Kinematics of types "C", "F", and "SM" magnetic contactors.

2. Explain in detail the "Roll" and "Wiping" action of "making" and "breaking" contact.

3. Operation and function of several types of relays including types "AT" and "TL".

4. Materials used and manufacturing methods employed in the production of parts.

5. Desirable characteristics of each material that decided its selection.

Questions

CONFERENCE 8

D. C. MOTORS

1. Function of D. C. Motor
   a. How is turning effort or torque developed
   b. Purpose of brushes
   c. Purpose of commutator

2. Mechanical Construction of sleeve bearing D. C. Motor
   Example: General assembly drawing 11-J-473 plus sketch of sleeve bearing.
   a. Frame: (1) Function, (2) Construction, (3) Material, (4) Strength, (5) Feet and holding down bolts.
   b. Brackets: (1) Function, (2) Construction, (3) Material, (4) Strength, (5) Bearing housing.
   c. Bearings: (1) Purpose, (2) Construction, (3) Material, (4) Oil grooves, (5) Oil rings, (6) Load carrying capacity.
   d. Poles: (1) Construction, (2) Material.
   e. Brush Holder: (1) Purpose, (2) Material, (3) Required strength.
   f. Shaft: (1) Purpose, (2) Material, (3) Required strength, (4) Critical speed.
   g. Armature: (1) Commutator construction and stresses encountered, (2) End plates, (3) Banding, (4) Wedges, (5) Vents
   h. Ventilation

3. Mechanical Construction of D. C. roller bearing mill motor.
   Example: General assembly drawing 21-A-187.
   a. Frame
   b. Bearing Housings: (1) Purpose, (2) Construction, (3) Material.
   c. Bearings: (1) Purpose, (2) Type, (3) Lubrication, (4) Load carrying capacity.
   d. Poles
   e. Brush Holders
   f. Shaft
   g. Armature: (1) Construction, (2) Reason for ruggedness.
   h. Ventilation

4. Methods used in connecting motor to driven machines.
   a. Flat belt drive: (1) Effective pull, (2) Total pull, (3) Speed, (4) Arc of contact.
   b. Vee belt drive: (1) Effective pull, (2) Total pull, (3) Speed, (4) Arc of contact.
   c. Chain drive: (1) Pull, (2) Speed
   d. Gear drive: (1) Tooth load, (2) Speed
   e. Couplings: (1) Flexible, (2) Solid

5. Vertical Ball Bearing D. C. Motor
   Example: General assembly drawing 11-J-903
   a. Bearings: (1) Upper, (2) Lower
   b. Lubrication and lubricating system

Questions

CONFERENCE 8 9

INDUCTION MOTORS

1. What is an Electric Motor?

2. Difference between A. C. and D. C. Motors.

3. The mechanical parts and their assembly.

4. Kinds of materials used for various parts of motors.

5. Typical applications of induction motors.

6. Mechanical considerations.

7. Motor Generator Sets and latest types of bed plates used for M. G. Sets.

8. Discussion of the application and general construction of the induction regulator.

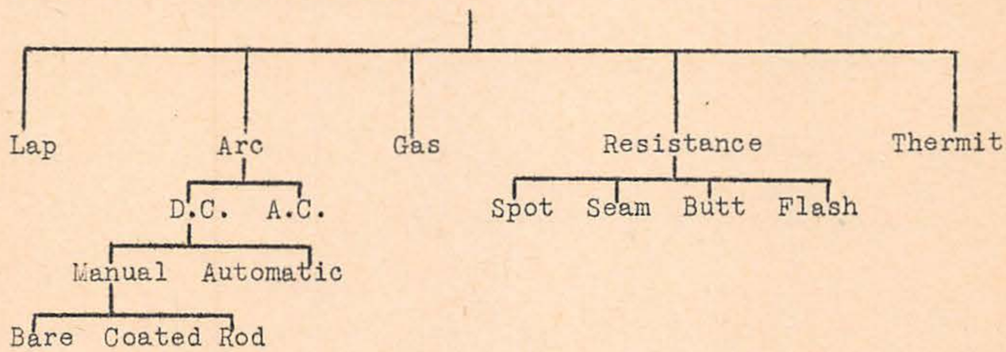
Questions

CONFERENCE 90

WELDING AND WELDING EQUIPMENT

1. Methods of machine manufacture
    a. Casting
    b. Riveting
    c. Forging
    d. Welding

2. Types of Welding and Welding Machines
    a. Their characteristics and uses



3. Demonstration of Arc Welding

4. Slides showing outstanding achievements of design using welding process.

Questions

CONFERENCE

TRANSPORTATION EQUIPMENT

Motors and Generators in the Transportation Field

1. History of electric traction

2. Application of motors and generators designed by Transportation Engineering Department

Motors	Generators & M.G. Sets
Street Railways D.C.	Lighting
Vehicles - Elec. Auto. D.C.	Exciters
- Battery road trucks	Auxiliary Generators
- " Industrial trucks	Main Generator on self-propelled locomotive and bus
Locomotives	Phase Converters
Industrial D.C.	Frequency Changers
Switchers A.C. & D.C.	Aircraft generators
Main Line	
D.C. 600 to 3000 V.	
A.C. Induction	
A.C. Single Phase Commutator	
Motor - Gen. Type	
Subway & Rapid Transit Cars	
Main line MU cars	
Mining locomotives	
Trolley Bus	
Gas Elec. Bus	
Diesel Elec. Bus.	
Diesel Elec. Switch Locomotives	
" " Streamliners	
Aircraft auxiliaries	

3. Design characteristics of Transportation machines.
   Ruggedness - severe service conditions
   Compactness
   Low weight
   High rating - class B insulation

4. Some typical motors and generators
   a. Street Railway
      Axle hung motor 510-A - Outline Dwg. 744365
      PCC motor - 1432 - Outline Dwg. 61B551
      Longitudinal Sec. 62A47
      Cross Sec. 62A48
   b. Diesel Elec. Bus
      Generator 191A Dwg. 92A651
      Motor 1435 Dwg. 92A726

TRANSPORTATION EQUIPMENT (continued)

c. Subway Motor

Outline	Dwg. 59A715
Frame	Dwg. 684391

d. Diesel Elec. Streamliner

Motor - Type 366E	(Outline	62A58
	(Long.Sec.	83A376
Generator - Type 486B2	(Outline	80A828
	(Long Sec.	12J479

e. Main Line A. C. Locomotives

Motor Type 428B	(Outline	83A336
	(Long Sec.	12J450

5. Field troubles often mechanical
   Characteristics required of Transportation draftsmen
   - Accuracy
   - Ability to calculate strength of parts
   - Memory

Questions

CONFERENCE

TRANSPORTATION EQUIPMENT

CONTROL

1. General set-up for control application and design
2. Types of vehicles
3. Motor arrangements parallel, series parallel, etc.
4. Transition
5. Starting and braking
6. Rate selection
7. Types of power apparatus
8. Types of controllers
9. Unit switch and magnetic switch
10. Sequence switch
11. Reverser

The Draftsman:

1. Equipment to design above apparatus
2. General attitude toward a design problem
3. Ability to coordinate and cooperate
4. Technical plus personal factors

Apparatus:

Visit F-1 and observe functions of master controller, accelerator, switch group and any other available equipment.

Visit 2-L and observe motor driven sequence switch.

Line Material

Questions

CONFERENCE

GEARING

1. Review of various types of tooth forms used with particular reference to the involute tooth form which is the most widely used tooth form at the present time.

2. Reasons for deviating from equal addendum, i. e., using long addendum pinions and short addendum gears.

3. Some of the reasons for adapting and using various pressure angle gearing.

4. Helical gearing vs. spur gearing

5. (a) Why some helical gears are cut with spur hobs instead of helical hobs.
   (b) How this affects center distance, pressure angle, helix angle, face widths, etc.

6. Review of the various types of gear units manufactured by the Nuttall Works and some of their applications.

   Illustrated by Nuttall gearing catalog and some typical assembly drawings.

Questions

CONFERENCE 48

MANUFACTURING PROCESSES
FOUNDRY PROCEDURE

Casting Design

When considering the design of a new casting the chief requirements of the particular application must govern the variables that enter into the making of any casting. At times machinability must be sacrificed for strength, or the weight and thickness must be increased to allow the metal to flow, or the design must be altered to eliminate shrinkage and so forth. Progress in the Foundries has kept pace with that of other lines of industry but the making of castings is still pretty much of an art based on judgement and experience. There are however a number of characteristics of all cast metals that should be kept in mind.

Overcoming shrinkage is one of the most difficult problems in the foundry. All cast metals are subject to two phases of it, one as the metal solidifies and one as the metal cools from the freezing point to room temperatures. The shrinkage that occurs during solidification is the cause of internal holes or porosity in castings, or holes or depressions on their top surface. To overcome it metal is supplied from a riser or feeder to compensate for it. The abrupt joining of thick and thin sections attaching heavy bosses to thin sections and using soft iron in thick sections are some causes of internal shrinkage troubles which should be avoided. The shrinkage that occurs after the metal solidifies is a contraction or reduction in the actual size of the casting that is due to cooling from elevated to room temperatures. Allowance for it is always made in the pattern shop when making patterns. Designers seldom need to consider it except in special cases such as fly wheels where a heavy hub and rim may be joined by a thin straight arm. In such cases, the arms which solidify and shrink long before the heavier sections, are apt to crack and pull away. This can be overcome by increasing the metal thickness in the arms or by giving the arms a curved shape that will spring but not crack under the shrinkage strains.

High strength and easy machining in a casting are not possible at the same time. They are approximately inversely proportional and one must be sacrificed to improve the other. Section thickness also affects the strength of the metal in the casting. The unit strength of the metal tends to vary inversely with the thickness of the section.

In designing for appearance it should be remembered that large flat horizontal surfaces are most difficult to cast. They should be curved or broken by an ornamental design if at all possible. Sharp corners cause molding difficulties that spoil the appearance.

They get battered in cleaning the casting and never look well on a finished casting. Narrow grooves and deep pockets seldom look good on a casting due to metal burning into the sand causing a rough dirty surface.

The use of external cores often mars the appearance of castings as the joint between cores and mold is always irregular. Ample draft on all vertical surfaces helps to improve the casting appearance as it permits the pattern to be taken from the mold without tearing it up.

Designers are always interested in cost and it should be kept in mind that the simplest and easiest casting to make will always have the lowest cost and will also present the best appearance. It is quite possible to make complicated castings but it is always expensive and frequently their appearance and physical properties are not satisfactory. Low cost and good looking castings must be made on the drawing board before they can be made in the foundry.

Pattern Design

Ordinarily the designer does not need to consider pattern making details when designing a casting other than to give an accurate estimate of the future activity. Occasions do arise when a wood pattern would be too fragile to handle in the foundry and a metal pattern must be made or that the parting lines are across nearly vertical surfaces and two part patterns must be substituted for one piece patterns but these are rare and the selection of the proper type of pattern is the designers most serious consideration. Foundry patterns are of several types, loose wood, loose metal mounted wood and mounted metal patterns. Their cost and life increases in the order named. Loose wood patterns should be built where there is a very limited activity over a short period of time. For a limited activity over a period of years a loose metal pattern is preferred. Mounted wood patterns are for limited activity and life but are built where the activity warrents using them on a mechanical molding unit or machine. Mounted metal patterns are built for high activity over an indefinite period of years. They are the most desirable from a standpoint of ease of operation and maintenance accuracy and uniformity of castings and attainment of lowest casting cost. It is always false economy to build wood patterns where metal patterns should be used as it invariably results in the wood pattern wearing and warping out of shape while still in active production. Castings from such patterns have a poor appearance and are not accurate or uniform. This causes high maintenance expense and manufacturing delays in both the foundry and machining sections which reflect directly or indirectly in the product cost.

Mounted patterns are usually used on molding machines that require operators less skilled and lower paid than the highly skilled men required to work with loose patterns. The cheapest, most accurate and uniform castings are always obtained from mounted metal patterns and they should be provided if the activity is sufficient.

Molding and Core Making

Sand molding of castings is divided into two classes, dry sand molding and green sand molding. Dry sand molding is used exclusively

for all large sized and some medium sized castings. Green sand molding is used for some medium sized and all small castings. The sand used for both classes of work is approximately the same except that coarser grades are used for larger castings. Dry sand molds are sprayed with graphite wash and thoroughly dried before being poured, while green sand molds are poured with the sand in the same moist condition in which it is rammed.

All molding sand is basically silica sand such as is found on lake or ocean beaches plus a properly mixed refractory clay. The so called natural molding sands are taken from deposits where these two materials have been mixed by nature in the proper proportion and quality. Synthetic sands are mechanical mixtures of the same two materials. The use of either natural or synthetic sand is largely a matter of choice and locality as good results can be obtained from either.

Care must be taken to see that the sand containes the proper amount of bond or strength, that is sufficiently open or permeable to allow the free escape of steam, that the grain size is uniform and small enough to give a satisfactory casting surface and that the clay bond is sufficiently refractory to withstand the heat of the molten metal without fusing to the casting. The sand must also be handled properly in making the mold. It must not be too wet to avoid generating excess steam when the mold is poured or rammed too hard to prevent the free escape of steam through the mold yet must be rammed hard enough to give a true impression of the pattern and not yield under the pressure of the molten metal.

Molds are rammed by hand, by pneumatic rammers, by the centrifugal force of high speed rotary impellers, by vertical jolting and by squeezing. Molds are always made in at least two sections with an accurate joint between them. The pattern which is completely embedded in sand after the mold is rammed except along the joint line, is withdrawn from the mold through the opern face or joint before the mold is closed. Channels for the flow of metal are cut directly in the sand from the outside of the mold to the desired location in the impression.

Dry sand cores are made from a baked silica sand and oil mixture to form recesses that are so located or of such a shape that they cannot be made an integral part of the mold. The cores are set into depressions in the mold which accurately located them in relation to the rest of the impression.

Cores are made by ramming a moistened mixture of silica or beach sand, linseed oil and corn flour into a box containing an impression of the section of the casting to be formed. The shape of the box acts as a print or locater to fit the core into a similar shaped depression in the mold. The cores are rammed by hand or by air pressure and are dumped out of the box onto plates for drying. The corn flour in the mixture serves to hold the sand in shape until baking starts. The real strength of the core is developed by baking the linseed base oil.it contains at about 400° F for about two hours. This gives an accurately shaped sand core that can be readily handled by hand. When

surrounded by molten metal it will disintegrate and fall from the casting.

The actual making of a casting sounds like a simple operation but it requires careful selection and intelligent use of materials to control the variables that enter making up of the metal mixture and melting in it, the recognition of the proper pouring temperature, the proper ramming of the sand to keep the casting true to pattern but soft enough that the metal will lie quietly against it and porous enough to permit the escape of moisture and gas but fine enough to prevent the penetration of the metal. The skill and supervision required are comparable to that of other line shop work.

Questions

MANUFACTURING PROCESSES
FOUNDRY PROCEDURE - CONTINUED

Melting Methods

Foundries take advantage of all known methods of melting metals. Some of the methods have been in use centuries while others have been developed within the last decade. Regardless of age, they have all been developed to a high degree of perfection. Fuels, refractories, controls and principals of combustion have all been studied and improved. The type of melting unit used is governed by the characteristics and quantity of the metal required and by the severity of the application for the particular alloy.

Brass and bronze are melted in gas, oil or coke fired crucible furnaces if the quantity required is small or the application requires a particularly high grade metal. Oil or gas fired reverberatory furnaces are used where large amounts of alloy are required at one time. Judicious use of fluxs and careful regulation of the heat supply are necessary to prevent the metal from oxidizing or absorbing gases during melting.

In making up the various brass and bronze mixtures the higher melting point metals are melted first and the lower melting point materials are fed in just before the mixture is ready to pour. Special alloys having a high affinity for oxygen are usually added to brass and bronze just before pouring to remove any oxygen the melt may have taken up. Silicon and phosphorus alloys of copper are most generally used. The amount added is insufficient to alloy with the melt but does act as a scavenger.

Indirect arc and induction type electric furnaces are also used to a limited extent for melting brass and bronze and some other non ferrous alloys having high melting points. Both are rather expensive to operate. The induction furnaces have the advantage that all the heat for melting is developed within the melt thereby eliminating all chances of contamination from the fuel.

Aluminum alloys are usually melted in gas or electrically heated crucible type furnaces although reverberatory furnaces are also used when large quantities of alloy are required. Precautions similar to those required for brass and bronze must be taken.

Cast iron is the most widely used of all casting metals. It is usually melted in a coupola but special grades or small quantities are often melted in arc type electric furnaces. The cupola is the simplest and most efficient type of metallurgical melting furnace. It is a circular vertical furnace using coke as fuel. Pig iron, scrap iron and scrap steel are the raw materials used. They are mixed with due regard for melting losses, to give the desired analysis and physical properties in the finished casting. The low cost of the raw materials required and the high efficiency of the melting furnaces make cupola cast iron the cheapest and most widely used of all cast metals. Various alloys

are often added to improve it for special applications and certain grades respond to heat treatment much as steel does.

Arc type furnaces of the direct and indirect type are sometimes used when small quantities of alloyed iron or other special grades are needed. The method has the advantage that it can be controlled to obtain any desired temperature or analysis which cannot be done in the cupola after it is in operation.

Cleaning, Finishing and Inspection

Casting, cleaning and finishing operations are to remove all sand adhering to the casting surface and to remove any fins or projections. The actual methods used vary with the size and metal in the casting.

Removal of sand adhering to the surface is the first step in cleaning castings. Small aluminum and brass castings aften come from the mold perfectly free of sand and go directly to the grinder. Brass castings that do not come from the mold clean are either tumbled dry or in barrels in running water or are sand blasted. Small and medium sized iron castings are usually tumbled dry to remove sand and to polish the surface somewhat. Intricate casting and those too large to tumble are shot or sand blasted. Very large castings are cleaned with pneumatic chipping hammers and brushes.

After removal of the sand small castings are ground by hand on emery wheels of the proper grade to remove any fins or lumps and go directly to the inspector. Larger castings, too big to be handled by hand, have the projections chipped off with pneumatic chipping hammers. Often they are also smoothed up by using portable grinders.

Casting inspection is usually for foundry defects only. Patterns used are accurately made and carefully checked before going to the foundry so it is usually assumed that casting dimensions are within foundry tolerances. Surface appearance, freedom from cracks, shrinkage, blow holes and proper location of cores are carefully checked before shipping the castings.

Questions

MANUFACTURING PROCESSES

FOUNDRY PROCEEDURE

CONFERENCE #51

Permanent Moulding

In permanent moulding, molten metal is poured into and held in a metallic mould or die until solidified under a gravity head. This involves specialized equipment and results in a product sharply differentiated from other casting processes.

The special characteristics of permanent moulded castings offer a number of economic benefits where a metallic process is used in large quantities.

1: The Permanent Moulding process affords a means of producing pieces at a rapid rate with a uniformity of structure, appearance, and dimensions.

2: It reduces or totally eliminates machining operations because of the dimensional accuracy of the product, and the ability to core holes.

3: Different kinds of metal may be cast into position, as studs, bushings and inserts for shock and wear resistance.

4: Pieces made by assembly of sheet metal or stampings can be reproduced as one casting where the integral construction gives greater strength and rigidity at considerably lower cost per piece without the need of an expensive series of punchings, forming, and drawing dies, and other jigs and fixtures.

Based on these characteristics they have been commercially applied on network, protection parts, circuit breaker deion type parts, levers, couplings, large nuts, brush holders, brush holder fingers, frames, etc.

Scope and Limitations: In considering the use of a permanent mould casting, the following characteristics should serve as a guide, but in complicated, elaborate, or doubtful cases advantage should be taken of the experience of one specialized in this method.

Size: In permanent moulding Aluminum Silicon the heaviest casting today is 6-1/2 pound with overall dimensions of 16-1/2" x 6-1/2". For Aluminum, Copper, Silicon the heaviest is 3 pound with overall dimensions of 2" x 14" and for Aluminum Bronze is 8-1/4 pound and dimensions of 5-3/4" x 10". This, of course, applies to our own works. Other manufacturers may have equipment for handling larger castings.

Section Thickness: On large castings metal thickness may be reduced to .187 to .250. Sections less than 5 inches in length or width may run as low as .125 inches. It is usually desirable to keep the wall thickness fairly uniform or at least to avoid abrupt changes in section.

Dimensional Accuracy: Commercial permanent mould castings are generally produced to tolerance limits of plus or minus 0.0015 inch per linear inch. When once the shrinkage of a particular casting has been determined by successive trial and re-working of the dies, much closer limits can be maintained on dimensions of 3 inches or more. Each job must be engineered with a specific tolerance in mind.

Dimensions measured perpendicular to the parting line are maintained within limits of minus nothing plus .010 inches in the larger castings, down to minus nothing plus .005 inches on small pieces.

Cores: Coring of required holes or cavities not only reduces machining operations but saves metal weight and permits the beneficial chilling action of the steel cores to be exerted throughout a greater part of the casting. Slight drafts are used to permit withdrawal without injury to cores or castings.

Hot Pressing Method

Method: Bar stock of the correct diameter is first cut to a pre-developed length. The cut off piece, or slug as it is generally called, is then heated and placed under a pre-heated die and forged. The forging presses used have a capacity of 200 to 1000 tons, depending on the amount of metal that must be displaced. They are operated at a speed of 50 to 100 R.P.M.

Materials: Virgin metal is used on all hot pressed forgings to produce a uniform analysis. This coupled with the hot pressed process, produces forgings of great strength and very fine uniform grain structure. The strength and non-porosity will often permit reducing weights of parts without effecting their utility, thereby saving considerable on cost of material. This feature alone often makes possible a saving over casting great enough to more than pay the machining or finishing cost. An interesting comparison of yellow brass as cast and forged is:

Analysis -	Copper	58%
	Lead	2%
	Zinc	Balance

Physical properties - Comparative

	Castings	Forgings
Tensile strength, pounds per square inch	20,000	40,000 to 55,000
Elongation in two inches	17%	20%
Brinell hardness	60	70 - 82
Approx. weight of forgings per cubic inch		.30 pounds

Other materials used for hot pressing are copper P.D.S. # 2632 and a Copper Silicon Alloy P.D.S.#7610.

Application: A few of the many places where hot pressed forgings can be used are parts for Mechanical Refrigeration, Electrical Goods, Radio Contacts, Wing Nuts, Hexigon Contact Nuts, and any place where non-ferrous parts are required. Forgings are ideal for use where gases, oils, or other liquids are confined under normal or mechanical pressure. There need be no fear of leaks, because the grain structure insures against this difficulty.

Limitations: There are several common factors which have an effect on the tolerances to which a piece can be held. They are

1. Variation in temperature of metal
2. Variation in temperature of die
3. Gradual wear on die
4. Variations in length and weight of slug.

The maximum life of dies at minimum cost is largely dependent on tolerance allowed, liberal fillets at corners, and draft on straight vertical details. The engineering drawing should specify the following minimums:

Tolerance - Dimension or diameter
Up to 1" plus or minus .005
1" and over plus or minus .010
Fillets - All possible - Minimum 1/16"
Draft - 1 to 3 degrees

Economic consideration versus Castings or Forgings:

Forgings -
1. Greater strength
2. Compact uniform grain structure
3. Leak proof parts
4. Smooth surfaces
5. Accurate surfaces
6. Lighter parts at no sacrifice of strength or other physical properties.
7. Economy in machining
8. Clean cut perfect threads
9. Lower piece cost

Castings -
1. Lower tool cost - pattern
2. Tools are not perishable - long life.

Questions

CONFERENCE #52

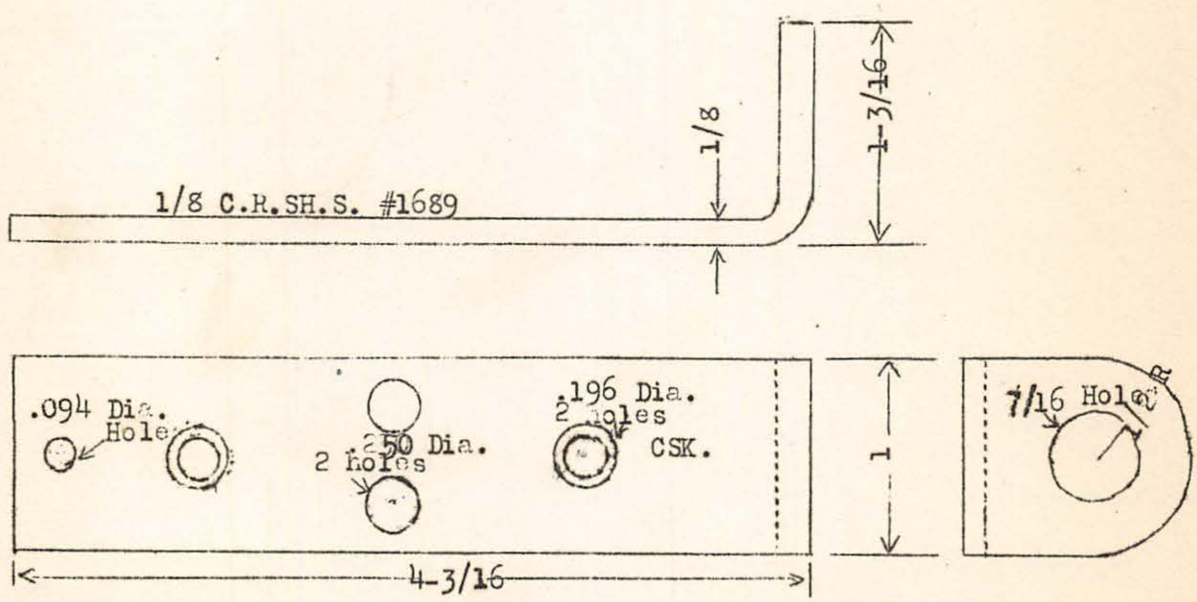
MANUFACTURING PROCESSES OF METAL STAMPING DETAILS.

Metal Stamping Details consist mainly of brackets, washers, spacers, laminations, contacts, metal covers, connectors, heating elements, etc., and are fabricated from steel, copper, brass, bronze, aluminum, lead, and various alloys in sheet or bar form.

There are numerous methods of manufacturing a metal stamping all of which have their own distinct economic advantages. The choice of method or combination or methods depends entirely upon the quantity involved, Materials used, tolerances required, and the appropriation allowed for die construction.

The shop terminology for the various methods being used are - "The Bench Method, The Simple Die Method, The Continental Die Method, The Universal Die Method, and the Stardard Die Method".

For illustration purposes the sequence of operations and an approximate time allowance for the bracket sketched as follows: Time is in decimal hours:-



The Bench Method. For approximately 20 pieces or less.

	Setup	Oper. Time
1. Shear length	.22	.00129
2. L.O., drill, csk, burr, bend, file radius	1.11	.16350
3. Clean and paint in Assembly Section		
	1.33	.16479

The Simple Die Method. For Approx. 20 to 250 pieces.

	Setup	Oper. Time
1. Shear strips	.29	.00036
2. Cut double length	.56	.00065
3. Cut in half	.38	.00090
4. Pierce 1 hole 7/16" Dia.	.49	.00180
5. Pierce 2 holes .196 Dia.	.73	.00360
6. Pierce 2 holes .250 Dia.	.73	.00360
7. Bend	.45	.00180
8. L. O. drill, burr .094 Dia. hole csk., & burr 2 holes.	.30	.02230
9. Clean and paint in Assembly Section		
	3.93	.03501

The Continental Die Method. For Approx. 250 to 2000 pieces.

1. Shear strips	.29	.00036
2. Pierce & cut off	.30	.00450
3. Bend	.45	.00180
4. Drill .094 Dia. hole	.26	.01250
5. Csk. & burr 2 holes	.25	.00700
6. Clean and paint in Assembly Section		
	1.55	.02616

The Universal Die Method. For Approx. 2000 to 10,000 pieces.

1. Shear strips	.29	.00036
2. Pierce and cut off	.40	.00250
3. Bend	.40	.00156
4. Drill, .094 Dia. hole	.26	.01000
5. Csk., & burr 2 holes	.25	.00450
6. Clean and paint in Assembly Section		
	1.60	.01892

The Standard Die Method. For Approx. 10,000 to 50,000 pieces.

1. Pierce and cut off	.30	.00125
2. Bend	.30	.00156
3. Drill .094 Dia. holes	.26	.01000
4. Csk. & burr 2 holes	.25	.00450
5. Clean and paint in Assembly Section		
	1.11	.01631

Special Setups on Standard Dies. For quantities over 50,000 pieces.

	Setup	Oper. Time
1. Pierce, cut off and bend	.75	.00065
2. Drill .094 Dia. hole	.26	.00500
3. Csk., & burr 2 holes	.25	.00450
4. Clean and paint in Assembly Section		
	1.26	..01015

The die cost for each succeeding method increases with each step. To determine which class a particular detail should follow, the difference in piece cost should be divided into the die cost. This will determine the number of pieces that must be made before the expenditure for dies is justified.

Questions

CONFERENCE #53

LAMINATION MANUFACTURE

In the manufacture of segment laminati ons there are several methods used, depending on design, siz , and quantity required. There are three kinds of segment dies, Compound, Closed Blanker, and Open Blanker.

A compound blanking die makes the complete lamination in one operation or stroke of machine. This typ of die is used for standard work and when the activity is la .

A closed blanker or outline die is similar to a compound die, except there are no slots or perforations. type of die may be used on a number of jobs where the length and width are the same.

The open blanker is the most active die. This die is open in the front and can be used for a large number of jobs. The back of this die is standard, but by adjusting the gauges the width may vary from three to fifteen inches.

The slotting operation on both the closed and open blanker is performed in the same way. This operation is performed in an automatic indexing machine. A radius indexing piece is an arm, that fits on the indexing machine with a radius for the given dimension. The radius piece must have two or three notches more than the number of slots given on the drawing.

The operations performed for making complete circle type (stator or rotor) laminations are similar to the segmental type. Type A or compound blanking dies are used for standard and large quantities. Type C or outline die makes the lamination complete except the slot. The slotting operation is performed on the automatic indexing machines. The indexing ring for this type of lamination has a notch for each slot.

For small activity orders, laminations are made with simple tools. A standard round hole die is used for a blanking die. If a die for the correct size is not available, then the next larger size is used and then trimmed on the automatic machines with a slot die. The center hole die must be to drawing size and must be located correctly, as the operations following are located from this hole. The keyway is slightly larger than the shaft and must be a good fit. The slotting operation is performed on the automatic machines, just as the type C dies are.

Inclined presses are used for segmental and circle laminations where the activity is large. These machines are set on forty-five degree angle. The stators are blanked in double die and fall into a chute where they are packed. e operator places these blanks in another packer where they e pierced and then drop through onto a conveyor belt through ther die where the punch out center and trimming operation done. The center that is punched out is used for the rotor the same motor.

CONFERENCE #54

HEAVY DRAWING & BLANKING OPERATIONS

Materials most generally used for boxes and covers are P.D.S. #4068, #1689, and #1550. #4068 is used most because of its deep drawing properties.

In some draws this steel cannot be used on account of the large permissable variation in thickness "about 10%". In that case #1689 is used, this steel is higher in price, but the thickness variation is much smaller and the drawing qualities practically the same as #4068.

P.D.S. #1550 is the cheapest of the three, but will not draw quite so well as the other two and has, like #4068, a large permissable thickness variation.

The materials are received in sheet form. This makes either a shearing or blanking operation necessary to reduce the sheet to the size required before drawing.

In the drawing operation there are generally two types of presses used, draw presses, a nd cushion presses. A draw press is one in which there is a double action in the head of the press, first a blank holder comes down and holds the material while a plunger follows and performs the draw. In a cushion press the blank holder is on the bottom and is held against the blank by either air or springs as the draw is being performed.

The purpose of the blank holder in drawing is to prevent the material from starting to wrinkle while the draw is being made. In most cases it is practically impossible to take out wrinkles onte they have been formed in the material. Another reason for keeping wrinkles out is that the material generally tears or fractures if not kept smooth while drawing.

In general, deeper draws can be made with a regular or double action draw press and the operation costs about twice as much as draws made with a cushion press. After the drawing operation is completed a trimming operation is generally necessary because in most cases the outside dimensions will vary on account of the variation in thickness of materials and the difficulty of making two draws exactly alike. Trimming operations are performed in a number of different ways. The method is determined by the amount of pieces to be made.

If the orders are large in quantity, a trimming die is made which performs the operation complete with one stroke of the press. If the quantity is small, trimming the straight parts of the sides or ends is done on a shear and rounded corners and irregular shapes on a simple die. This requires on an average 8 operations before the trimming is complete which makes it quite costly.

Questions

CONFERENCE #55
MANUFACTURING COST ANALYSIS

The purpose of a manufacturing cost analysis is to determine the most economical method of manufacture, and to determine the lowest cost for the quantity and quality of work to be produced.

Three departments are involved in making a cost analysis:

1. The Sales Department should be able to say what kind of a product they can sell to meet competition or market demands.

2. The Engineering Department should be checked as to design. Is the design such that it can be manufactured economically?

3. The shop should be checked as to availability of equipment that will best produce the parts at the lowest cost. Under the present set-up each division has a cost analysis man or a group of men who continually work on cost analysis under the direction of the superintendent.

The cost analysis is usually started because of loss of profit on some particular trading account. Frequently it is started by the Engineering Department or by the shop or Cost Department. In making a cost analysis a number of things must be taken into consideration. The most important of these are:

1. What activity is contemplated?

2. Is the design as made fully tooled in the shop to meet the activity required?

3. If the parts are not carried in stock would it be more economical to make in quantity and carry parts in stock?

4. Is the design suitable to manufacture on present shop equipment or should special equipment be purchased?

5. Could different materials be used to better advantages in the manufacture of the product?

6. Could more standard parts be used in the design?

7. Check tolerances on drawings to determine if they are actually required. (Possibly extra operations are necessary to meet the tolerances specified).

8. Could the design be modified to permit the use of materials in various forms: such as, Die Castings - Permanent Mold Castings - Extruded Metal Sections - Forging - Hot Pressings - Roll Formed Metals, etc.

9. Does the design lend itself to easy assembly? (Apparatus may be difficult to assemble due to construction of parts).

10. Has the design more features than competitors designs, which are used only for Sales talk, being practically of no use or convenience to customers?

CONFERENCE 56

MANUFACTURING PROCESSES

Coordinating of engineering design and factory equipment:

(a) Where is it going to be made?

(b) How many are going to be made?

(c) At what rate?

(d) What is the probable life of the design?

(e) How soon must it be in production?

(f) Should we make or buy outside?

Relation of feeder sections to assembly departments

Production control influences

Relation of items to other products manufactured

Questions

CONFERENCE 57

MANUFACTURING PROCESSES CONT'D.

Principles of interchangeable manufacture:

(a) Need for interchangeability

1. In manufacture - for assembly at low cost

2. In application to customer's use

3. In replacements of parts - detail or unit

(b) Standardization of details

1. Use of general industry and Engineering Society standards

2. Use of general Company standards

3. Development of departmental standards

(c) Development of standard practices to permit combination of sizes, in higher production set-ups

(d) Use of tolerances

1. Relative accuracy

2. Selective assembly

(e) Influence of manufacturing equipment available

Questions

CONFERENCE 58

PURPOSE AND METHODS OF INSPECTION

1. Definition of Inspection

2. Purpose of Inspection

3. What to look for in Inspection

4. How much Inspection - roving - sample - patrol - 100%

5. Where inspect- Raw Mill Inspection - Feeder - Assembly

6. Attitude of Inspector toward design

7. Attitude of designer toward Inspection

Questions

CONFERENCE 59

INSPECTION ORGANIZATION

1. The Inspection Organization
2. Building the Inspection Organization Qualification and Training
3. Relation of Inspection Department to Sales Department sell and keep material sold
4. Inspection system and need of following routine
5. Engineering contact man in the shop
6. Draftsman should familiarize himself with shop equipment and processes
7. Field Adjustment Charges

Questions

CONFERENCE 60

INSPECTION, TOOLS AND EQUIPMENT

1. Tools of Inspectors - gages - drawings - manufacturing information - specifications
2. Standard of Quality - who establishes it
3. Flow of Influence in Inspection Department
4. Tolerances must be established - Inspector - Draftsman and engineer - dies for each piece and drill on assembly
5. Cost of tools for controlling various tolerances
6. Chemical and physical analysis - spark test
7. The toolroom

Questions

CONFERENCE 61

TESTING

Industrial Motor Apparatus Testing

Check to stock order information - safety

All rotating apparatus

Mechanical inspection - Oil rings, oil leaks, end play, bearing temps., noise, insulation balance

Complete engineering, commercial and witness tests

D. C. Machines -	(Brush position	Motors	Generators
Series	(Commutation	Speed	Regulation
Shunt		Torque	Temperature
Compound		Temperature	Efficiency
		Efficiency-(Output)	saturation
		Saturation-(Input)	

Losses: Copper, Iron, load, brush, friction and windage

A. C. Machines: Induction motors, commutating motors, synchronous motors and generators

Induction motors
Characteristics: Speed, torque, power factor, efficiency, temperature, saturation
Losses: Copper, iron, load, friction and windage

Commutating motors
Characteristics: Neutral location, commutation speed, torque, power factor, efficiency and temperature, saturation.

Synchronous motors
Characteristics: Efficiency, torque (starting, pull-in, pull-out) Temperature, saturation

Synchronous Generators: Efficiency, regulation, temperature, wave form, saturation

Industrial Control: Contactors, contact resistance, minimum volts pull-in, noise, temperature

Across the line starters. No voltage, overload, overspeed. Reduced voltage starters. Reverse current, reverse power protection. Interlocking. Reversers. Sequence Testing.

Questions

CONFERENCE

TESTING

Generator Apparatus Testing

Check to stock order information - safety

All apparatus inspection for noise, oil rings, oil leaks, end play, bearing temperatures, and insulation. Balance air gap records.

Complete engineering, commercial and witness tests

All D.C. Machines - Characteristics

Brush position and commutation

Motors	Generators
Speed	Regulation
Temperature	Temperature
Efficiency	Efficiency
Saturation	Saturation

Losses: Copper, iron, load, brush, friction and windage

Induction Motors

Characteristics: Saturation, speed, torque, power factor, efficiency, temperature

Losses: Copper, iron, load, friction and windage

Synchronous Machines

Motors	Generators
Saturation	T.I.F.
Efficiency	Saturation
Torque (starting pull-in, pull-out)	Efficiency
	Regulation
	Temperature
	Wave form

Losses: Copper, iron, load, friction and windage

Induction Regulators

Regulation
Losses (Copper, iron and load)
Temperature

Power Rectifiers

Regulation
Efficiency
Temperature

Questions

CONFERENCE

TESTING 47

Switchgear Apparatus Testing

Testing information: Safety: interchangeability of parts

Instrument Laboratory

Calibration and maintenance of all electrical instruments and pyrometers.

Details

Switches, resistors, rheostats, network protectors, voltage regulators

Circuit Breakers-Insulation test

D.C.-Contact drop, calibration of overload, time delay and reverse current trip. Operation of shunt, overspeed and no voltage trips, temperature and rupturing capacity.

A.C.-Contact drop, noise, calibration of tripping mechanism -Deion type.

Oil Circuit Breakers-
Contacts, oil leaks, calibration of trip. Bushing tests, current transformer ratios.

Electrically Operated-
Closing, latching and tripping

Switchboards

Check all wiring for clearances and agreement with diagram, indicating and integrating meters and relays, the ratio and polarity of all instrument transformers, and the correct functioning of all apparatus.

Automatic Switching Equipment

Check all wiring for agreement with diagram and proper clearance, and all apparatus for correct functioning of parts and sequence of operations.

Steel Clad Switchgear Trucks and Cells

Check operation of all circuit breakers, relays and meters and the interchangeability of duplicate units. All interlocking must function correctly.

Lightning Arresters

Check the performance of individual rods and discs and functioning of completed arrester.

CONFERENCE U4

TESTING

Transportation Apparatus Testing

Check to stock order information-safety.

D.C. Railway Bus Motors

Characteristics: Commutation, saturation, speed, torque, temperature, efficiency, balance.

Losses: Copper, iron, load, brush, friction and windage.

Gas or Oil Electric Generators

Characteristics: Commutation, saturation, regulation,, temperature efficiency, balance.

Losses: Copper, iron, load, brush, friction and windage.

D.C. Control - Contacts, sequence, rupturing ability, calibration of relays, and circuit breakers.

A.C. Control- Contacts, sequence, rupturing ability, calibration of relays, and circuit breakers.

Questions.

CONFERENCE

TESTING

Capacitors

Check for correct capacitance, losses and insulation.

Questions

CONFERENCE 65

PATENT DRAFTING

OBJECTIVE

The purpose of a patent drawing is to clearly convey a picture or illustration of an inventor's ideas so that a clear understanding of the invention may be had, not only by one trained in the particular art covered, but by the layman as well. The patent draftsman must keep this fact in mind and illustrate the invention accordingly. Patent drafting differs somewhat from other lines of drafting inasmuch as patent drawings are not always drawn to scale.

Exploded views and perspective drawings are quite frequently used. Dimensions are not specified unless certain specific dimensions are an important factor in the invention. Reference characters are used on patent drawings to designate different parts of the machine in accordance with the specification or description of the invention. Although not always drawn to scale, proportion must be taken into consideration in most cases, especially in certain types of drawings such as schematic illustrations and wiring diagrams where scale and proportion are not used.

A patent draftsman's work varies, he does not specialize in one line of apparatus or articles of manufacture as other draftsmen usually do. As a rule each job is entirely different than the one preceding and new problems must be met.

PATENT OFFICE RULES

Patent draftsmen are governed by rules of patent practice of the United States Patent Office. The Patent Office has standard symbols for electrical apparatus, colors, cross sections of various materials, etc., that are embodied in the rules of practice. The symbols differ somewhat from those in general use in other lines of drafting.

A design patent, when filed, must be accompanied by a drawing, and it must cover a new, original and ornamental design for an article of manufacture. Design drawings must conform to the same rules laid down for drawings of mechanical inventions with the exception that the views are usually shown in elevation, surface shaded to bring out the contour and design with an artistic touch, so as to present a picture that will be pleasing to the eye. Broken lines are never used in design drawings, that is to say, hidden parts are never shown in dotted lines as may be done in a mechanical drawing. Reference characters are not used on design drawings.

REQUIREMENTS OF U.S. PATENT OFFICE

The applicant for a patent is required by law to furnish a drawing of his invention whenever the nature of the case admits of it.

The drawing must show every feature of the invention covered by the claims, and the figures should be consecutively numbered if possible.

When the invention consists of an improvement on an old machine the drawing must exhibit, in one or more views, the invention itself, separate from the old structure, and also in another view, so much only of the old structure as will suffice to show the connection of the invention therewith.

Two editions of patent drawings are printed and published--one for office use, certified copies, etc. of the size and character of those attached to patents, the work being about 6 x 9-1/2 inches; and one reduction of a selected portion of each drawing for the Official Patent Office Gazette.

This work is done by the photolithographic process, and therefore the character of each original drawing must be brought as nearly as possible to a uniform standard of excellence, suited to the requirements of the process, to give the best results, in the interests of inventors, of the office and of the public. The following rules are rigidly enforced, and any departure from them is certain to cause delay in the examination of an application for letters patent:

(a) Drawings must be made upon pure white paper of a thickness corresponding to two-sheet or three-sheet Bristol board. The surface of the paper must be calendered and smooth. India ink alone must be used, to secure perfectly black and solid lines.

(b) The size of a sheet on which a drawing is made must be exactly 10 x 15 inches. One inch from its edges a single marginal line is to be drawn, leaving the "sight" precisely 8 x 13 inches. Within this margin all work and signatures must be included. One of the shorter sides of the sheet is regarded as its top, and, measuring downwardly from the marginal line, a space of not less than 1-1/4 inches is to be left blank for the heading of title, name, number and date. A drawing for a trade mark registration differs from mechanical and design drawings inasmuch as the size of a sheet on which a trade mark drawing is made must be exactly 8 x 13 inches. Three-fourths of an inch from its edges a single marginal line is to be drawn, leaving the "sight" precisely 6-1/2 x 11-1/2 inches. Within this margin all work and signatures must be included. One of the shorter sides of the sheet must be regarded as its top.

(c) All drawings must be made with pen only. Every line and letter (signatures included) must be absolutely black. This direction applies to all lines, however fine, to shading, and to lines representing cut surfaces in sectional views. All lines must be clean, sharp and solid, and they must not be too fine or crowded. Surface shading, when used, should be open. Sectional shading should be made by oblique parallel lines, which may be about one-twentieth of an inch apart. Solid black should not be used for sectional or surface shading. Free-hand work should be avoided where it is possible to do so.

(d) Drawings should be made with the fewest lines possible, consistent with clearness. By the observation of this rule, the effectiveness of the work after reduction will be much increased. Shading (except on sectional views) should be used only on convex and concave surfaces, where it should be used sparingly, and even there be dispensed with if the drawing is otherwise well executed. The plane upon which a sectional view is taken should be indicated on the general view by a broken or dotted line, which should be designated by numerals corresponding to the number of the sectional view. Heavy lines on the shade sides of objects should be used, except where they tend to thicken the work and obscure letters of reference. The light is always supposed to come from the upper left-hand corner at an angle of 45°.

(e) The scale to which a drawing is made ought to be large enough to show the mechanism without crowding, and two or more sheets should be used if one does not give sufficient room to accomplish this end; but the number of sheets must never be more than is absolutely necessary.

(f) The different views should be consecutively numbered. Letters and figures of reference must be carefully formed and should, if possible, be at least one-eighth of an inch in height, so that they may bear reduction to one twenty-fourth of an inch; and they may be much larger when there is sufficient room. In close and complex parts of drawings, they must be so placed as not to interfere with a thorough comprehension of the same, and therefore should rarely cross or mingle with the lines. When necessarily grouped around a certain part they should be placed at a little distance, where there is available space, and connected by lines with the parts to which they refer. They should not be placed upon shaded surfaces, but when it is difficult to avoid this, a blank space must be left in the shading where the letter occurs, so that it shall appear perfectly distinct and separate from the work. If the same part of an invention appears in more than one view of the drawing, it must always be represented by the same character, and the same character must never be used to designate different parts.

(g) The signature of the applicant should be placed at the lower right-hand corner of each sheet, and the signatures of the witnesses, if any, at the lower left-hand corner, all within the marginal line, but in no instance should they trespass upon the drawings. The title should be written with pencil on the back of the sheet. The permanent names and title constituting the heading will be applied subsequently by the office in uniform style.

(h) All views on the same sheet must stand in the same direction and must, if possible, stand so that they can be read with the sheet held in an upright position. If views longer than the width of the sheet are necessary for the proper illustration

of the invention, the sheet may be turned on its side. The space for heading must then be reserved at the right and the signatures placed at the left, occupying the same space and position as in the upright views and being horizontal when the sheet is held in an upright position. One figure must not be placed upon another or within the outline of another.

(i) As a rule, one view only of each invention can be shown in the Gazette illustrations. The selection of that portion of a drawing best calculated to explain the nature of the specific improvement would be facilitated, and the final result improved by the judicious execution of a figure with express reference to the Gazette, but which must at the same time serve as one of the figures referred to in the specification. For this purpose the figure may be a plan, elevation, section or perspective view, according to the judgment of the draftsman. All its parts should be especially open and distinct, with very little or no shading, and it must illustrate the invention claimed only, to the exclusion of all other details. When well executed it will be used without curtailment or change, but any excessive fineness or crowding or unnecessary elaborateness of detail will necessitate its exclusion from the Gazette.

(j) Drawings transmitted to the office should be sent flat, protected by a sheet of heavy binder's board; or should be rolled for transmission in a suitable mailing tube, but should never be folded.

(k) An agent's or attorney's stamp, or advertisement, or written address will not be permitted upon the face of a drawing within or without the marginal line.

In reissue applications the drawings upon which the original patent was issued may be used upon the filing of suitable permanent photographic copies thereof, if no changes are to be made in the drawings.

The foregoing rules relating to drawings are rigidly enforced. A drawing not executed in conformity thereto may be admitted for purposes of examination if it sufficiently illustrates the invention, but in such case the drawing must be corrected or a new one furnished before the application will be allowed. The necessary corrections will be made by the office, upon applicant's request and at his expense.

Applicants are advised to employ competent draftsmen to make their drawings.

The office will furnish the drawings at cost, as promptly as its draftsmen can make them, for applicants who can not otherwise conveniently procure them.

COMPANY REQUIREMENTS

Patent draftsmen must be competent and thoroughly understand all the requirements of the Patent Office in respect to the preparation of drawings as well as a fair knowledge of the patent procedure in general. They must have either mechanical or electrical drafting training.

Electrical circuits are transposed from our engineering diagrams to conform to the Patent Office requirements. To do this the draftsman must thoroughly understand electrical circuits.

Patent draftsmen should be experienced in making freehand sketches. In many instances he is required to do so where complicated mechanisms are involved. Such experience is a valuable asset in assisting inventors in putting their ideas on paper.

The general procedure of preparing patent drawings is as follows:

(a) Inventor's disclosure must be studied and understood.

(b) Consult the attorney who is to prepare the application as to what drawings he will need in preparation of the case.

(c) Interview the inventor when more information is needed to complete the disclosure.

(d) Determine arrangement of views and make the necessary freehand sketches preparatory to making the drawings.

(e) Make pencil drawings and check them with the disclosure.

(f) Drawings are given to the patent attorney to prepare the specification, after which he submits it with the drawings for the approval of the inventor.

(g) Drawings are then inked, checked against the specification and completed for filing in the Patent Office.

(h) Negative or brown prints are made from the drawings for our files. The negative is used to make blue prints when needed.

The preparation of various charts and enlarged drawings to be used as exhibits in interferences and infringement suits are also a part of a patent draftsman's duties.

Questions

CONFERENCE 66

MANUFACTURING COSTS

I. Organization and Personnel of Accounting Department:) Attached
)
II. Organization and Personnel of Industrial Accounts Division:) Sheets

III. Manufacturing Cost:
Manufacturing cost is divided into three divisions termed the "elements of cost". These elements are:

1. Direct Material. The known quantity of material which enters production directly and is charged to each unit of product.

2. Direct Labor. The cost of direct labor is the wages paid to those employes working directly on the product or other cost unit, that is, to the extent that they can be definitely measured and allocated to the unit.

3. Manufacturing Overhead or Indirect Expense. This item includes the cost of all indirect supplies, indirect labor, and miscellaneous manufacturing expense, any part of which cannot be readily allocated to any one unit of production.

IV. How Costs Are Determined:

1. The Time Study Department establishes a time value (allowance in terms of hours).

2. The Engineering Department specifies in the bill of material on drawing or manufacturing information, the kind and quantity of material required.

3. The Cost Accounting Department establishes standard costing rates (described more in detail later).

4. The unit cost is determined by:
   (a) Pricing a standard quantity of material required by unit of product at standard material prices.
   (b) The time value times the standard costing rate, which included a direct labor rate and a direct expense rate, is the standard cost of labor and overhead.
   (c) The unit cost is the sume of (a) and (b)

V. How Costs Are Controlled:

Standard costs are controlled by the analysis of variances. Standard labor rates are used for costing the direct labor and the difference between the standard labor rates and the actual amount paid for productive labor is developed and reported as labor variance. Standard expense or overhead rates are established for each costing center. These standard expense rates are used to calculate the expense portion of cost. The difference between the standard expense rates

multiplied by the productive hours and the actual amount of money spent for expense operations and materials is developed and reported as expense variance. In practically all cases the company has established standard material prices for productive materials and in many cases for expense materials. The difference between the standard material prices and the actual amount paid for materials is material price variance.

At some works and departments, a standard has also been developed for the amount of material to be used for each unit of production. The difference between the standard amount allowed for the unit of product and the actual amount of material consumed is developed and reported as material usage variance. This plan is called material control. Where material control is not used, the difference between the actual amount of material consumed and the amount included in costs is developed annually as an inventory adjustment.

VI. Cost Center:

A cost center is a group of identical or similar machines, a bench or benches at which work of the same or similar character is performed, or an assembly or machining group. A cost center is usually one or more groups of a section. A separate standard costing rate is established for each cost center. Enough cost centers must be established to assure the management that equitable costs can be determined.

VII. Standard Costing Rates:

A standard costing rate is composed of two parts:

1. A standard labor rate which includes the direct labor rate, the extra allowance rate, and the set-up rate.

2. The standard expense rate which includes the direct expense rate, the departmental rate, and the general prorated expense rate.

VIII. Variances:

There are three major classes of manufacturing variances:

1. Material Variances. Variations of material costs from standard are of two principal kinds:
   (a) Material price variance which is the difference between the actual price and the standard price of the standard quantity required.
   (b) Material usage variance which is the difference between the standard cost of the material actually used and the standard cost of the material that should have been used under standard conditions.

2. Labor Variance. Theoretically labor variances are divided into two general groups, wage rate variations and efficiency variations. Actually, in this company, the analysis of labor variances divides the labor variance into four component parts:
   (a) Rates
   (b) Efficiency
   (c) Extra allowance
   (d) Set-ups

3. Indirect Manufacturing Expense or Manufacturing Overhead Variances

   The manufacturing expense variances are divided into volume variance and controllable variances.
   (a) Volume variances is the variation (plus or minus) caused by current changes in the shop load. The standard expense budgets are determined for a normal volume of product, any change in the shop load affects these standard budgets. Volume variance is determined by subtracting the budget allowance from the cleared in cost.

   (b) Controllable variance is determined by subtracting the actual expense from the budget allowance. The controllable variance is the variation of actual expense above or below the budget allowance as established by the standard expense budget.

IX. Actual Costs Versus Standard Costs:

<u>Actual Costs</u>	<u>Standard Costs</u>
1. Actual costs cannot be determined until after manufacture is completed.	1. Cost may be completed before manufacture is completed.
2. Actual cost of same unit will be different every time the unit is manufactured.	2. Development of variances gives better control of expense and costs.
3. Management cannot make cost comparisons as readily with actual costs as with standard costs.	3. Standard costing rates and standard costs simplify inventory control. Also reduce work necessary to price inventory.
	4. Standard costs are better suited for furnishing negotiation prices to the Sales Department
	5. More economical to operate a standard cost system.

In the strictest sense, no actual costs can be determined. To even approach an actual cost it is extremely expensive and requires too much time for practical use. The actual amount of direct labor expended on a product and the actual amount of direct material consumed can, in most cases, be determined. It is only possible, however, to approximate the amount of expense materials consumed, the amount of maintenance required and the amount of supervision necessary. The "so-called actual costs" usually amount to a determination of the actual amount of labor expended at standard labor rates, the actual amount of material consumed at standard material prices and an average amount of overhead for the period under consideration. Standard costs on the other hand are readily determined by the means described above and lend themselves to estimating negotiating prior to the time the productive operations are performed.

Questions

CONFERENCE 67

ENGINEERING AND DEVELOPMENT ACCOUNTING

Engineering and development are very important features in the operations of an electrical manufacturing company, perhaps more so than in any other industry. The nature of the products and apparatus marketed demands that the company maintain a highly efficient engineering organization in order to:

1. Guarantee a high standard for its products.
2. Meet the many special requirements demanded by the customers.
3. Be constantly on the alert to discover new applications for the apparatus manufactured.
4. Carry on research work in order that new products may be developed which can be marketed profitably.

Development expenditures are divided into two main groups which are known as "engineering development costs" and "shop development costs". The engineering development costs include the following types of expenditures:

1. Engineering time and expense required in designing the apparatus.
2. Time and expense of the draftsmen, incurred in preparation of the drawings.
3. Time and expense incurred in preparing the manufacturing information for the shop after the design and drafting work has been completed.

The shop development expenditures consist of the following classes of expenses incurred in the shop sections:

1. Cost of making patterns.
2. Tool designers' expense and the cost of the tools.
3. Cost of dies and coil formers.
4. Engineering tests.
5. Extra testing.
6. Cost of changes made during the manufacture of the apparatus in order to improve the design, reduce costs, etc.
7. Expense incurred in making models.

The engineering and shop development expenditures referred to in the preceding paragraphs are incurred primarily on two distinct divisions of development orders which are classified and accounted for as:

1. Standard development (Including Research Development).
2. Customers' Orders development.

Standard development expenditures are expenditures incurred in:

(a) Maintaining a high standard for existing lines of products.
(b) Discovering new lines of apparatus or new products.

This class of development expense is financed and controlled by fixed annual appropriations granted to each Operating Division by the Management,

through the Director of Budgets. After receipt of the official appropriations, each engineering department prepares a development program which divides the contemplated development work into two different classes. These classes are known as:

1. Major development - Consists of development in connection with pioneer or research work on new lines of apparatus or new products of prime importance.

2. Minor development - Covers development incurred in connection with maintenance of existing lines of products and apparatus in order to meet competitive conditions.

Each development program is divided into subjects to each of which is assigned a five digit budget number. In order to facilitate the identification of these budget numbers throughout the organization, the first three digits of the budget number are identical to the first three digits of the statement code to which the work applies. The last two digits denote the numerical sequence of the budget. The total departmental appropriation is assigned to these various budgets and specific amounts are allotted for engineering, shop costs, and tool development.

Additional analysis is obtained by use of orders which are known as 6- and 7- orders. Engineering and shop costs are accumulated on the 6- orders, and the tool development expenses are accumulated on the 7- orders. Monthly statements are prepared for each engineering department, which furnish information regarding the appropriations and expenditures for each order and budget.

Development expenditures incurred on customer's orders are due primarily to the fact that the customer has ordered apparatus which we do not carry in stock. Development pertaining to customers' orders is divided into the following two classes and is so accounted for when cleared to operations:

1. Special development - Covers the development expenditures on orders for truly special apparatus of limited application for which repeat orders will probably not be secured. The cost of this class of development is expected to be recovered in the selling price of the particular order on which the money is spent.

2. Routine development - Covers the development expenditures on orders of a routine nature such as:
   (a) Orders for standard or semi-standard apparatus.
   (b) Orders for non-standard apparatus for which repeat orders will probably be received.
   (c) The large volume of orders where the individual order development cost is only small.

The distinction as to whether a customer's order is special or routine, is decided by the design engineer at the time he receives the shop order reading from the order service group. He indicates the classification and records the estimated development in the spaces provided on the shop order reading. This information is later transcribed, by the manufacturing information clerk, to forms which are used by the Accounting Department to accumulate the development costs.

The engineering and drafting hours on special, routine and standard development orders are reported to the Accounting Department on monthly time reports. Separate reports are required for engineers and draftsmen, because separate costing rates are applied to each. The hours reported on the time reports are converted into dollar values. The rates used in converting these hours to dollar values consist of the average hourly wage for each payroll division, plus the overhead rate calculated from formulae approved by the Director of Budgets Office. The values thus calculated become the monthly allowed expenses for this particular phase of the department's activity. Postings to the order cost records are made for the special and standard development items and the values covering routine development are cleared to the proper account identified to the statement code. The engineering expense accumulated on the special and standard development orders is cleared currently to the authorized accounts and is also identified to the statement code.

The hours reported are based on standard allowances which have been established for the various classes of orders and drawings. The orders handled by the engineering departments are divided into classes, based on the complexity of the work or drawings. Fixed hourly allowances based a study of the operations over a definite period, are established for each class of work. Sometimes, due to the limited experience on orders for certain types of apparatus, it is impossible to classify the orders. In these cases, the actual hours are used as the allowed hours.

Shop special and routine development expenditures are accumulated by the works accounting divisions identified to the specific shop order to which they apply. The authorization for incurring such expenditures is initiated by the engineering departments with the exception of the authorization for tool expenditures, which is initiated by the tool supervisor. Expenditures on routine development orders are cleared monthly to operations, identified to the statement code. Expenditures on special development orders are not cleared to operations until the billing is made to the customer.

In addition to the engineering work on the regular development accounts previously referred to, there are several other engineering activities. Prominent among these is the expense which appears in operating costs as Consulting and Application Engineering. This item covers the following activities:

1. Miscellaneous Engineering Department - Covers the salaries and expenses of the headquarters consulting engineers.

2. District Engineering - Covers the salaries and expenses of engineers located in the districts. These men assist the district sales and service departments in the various application and design problems encountered.

3. Marine Engineering - Covers the salaries and expenses of the engineers who study the application and coordinating questions relating to marine problems.

4. Central Station Engineering - Covers the salaries and expenses of the engineers engaged in the application and coordinating work pertaining to Central Station apparatus.

5. Special M & P Laboratory Depreciation - Covers the depreciation charges on certain equipment in the engineering laboratories on which the rate is too high to include in the standard costing rates.

The Consulting and Application Engineering expense is financed by an annual fixed appropriation granted to each department, and the monthly budget allowance is distrubuted to Operating Divisions based on an effort schedule.

The activities of the following departments are also included as part of the engineering expenses:

1. Foreign and Development Engineering - This department handles all requests for technical and manufacturing information received from the foreign companies with whom we have associate agreements. The total expenses of this department are charged to the International and Canadian Companies.

2. M & P and Research Laboratory Testing Work - In addition to the regular development work performed by these departments, they also handle numerous productive orders in their testing laboratories. This work is authorized by orders and requisitions and the distribution is made to the accounts shown thereon.

3. Clerical Engineering - This department's work includes the following activities:
   - (a) Manufacturing Information Section
   - (b) Renewal Parts Order Section
   - (c) Blueprint Section
   - (d) Photograph Section
   - (e) Catalog Section
   - (f) Records and Vault Section
   - (g) Style Record Section

   The allowed expenses of this department (excluding Catalog Section) are distributed to engineering departments on the basis of the service rendered the various departments. The allowed expense of the Catalog Section is included as part of the Sales Data expense.

Operating statements are prepared for each engineering department. These statements show the actual monthly expenses of the department in respect to salaries, traveling expense, stationery, tracing cloth, meals, errors, taxes, rent, depreciation, etc. They also disclose the monthly allowed expenses of the department, such as the productive time applied to the development accounts, the monthly portion of the fixed annual appropriations for consulting and application engineering expense, and productive time applied to other specific orders and requisitions. The difference between the monthly actual and the monthly allowed expense is recorded as variance. Accumulated totals are shown for actual and allowed expense, and also for variance.

CONFERENCE 68

SERVICE DEPARTMENT

A brief outline of the history, organization, and what may be termed the ideals and traditions, as well as the activities, of the Service Department should be helpful to the Draftsman.

The Service Department has a very positive interest in the Company's drafting organization because our service representatives are dependent upon the Draftsman for much of the information required to install, assemble, reconstruct, and repair apparatus manufactured by the Company. Sometimes this information is useful in attempts to improve apparatus made by other manufacturing companies.

About 1899 what would now be termed service representatives were established in several of the Company's District offices. These men handled erection, investigation, and field test work as well as minor repair work. Apparatus requiring major repairs was sent to the factory, or, if the size of the apparatus or other conditions warranted field work, men and materials were sent from the factory and repairs made at the operating plant. Between 1906 and 1920 the responsibilities of the Erecting Department were greatly enlarged. Many district locations were established, the erecting of steam apparatus was taken over, repair shops were installed, manufacture of switchboard and general renewal parts was established, District Office accounting inaugurated, and in general the principles of service to customers and local districts was more broadly developed.

The activities of the Service Department now include field assembly, erection of electrical, steam, and auxiliary apparatus, field investigation and test work, field reconstruction and repair work, service shop repair work (which is not confined to Westinghouse apparatus only), building switchboards, assemblying transformers and motors, manufacture of panelboards and boxes, and, under the direction of the district engineering organization, plant analysis and application engineering.

As it is the ideal of the power companies to keep power on the line at all times, so it is the ideal of the Service Department to keep Westinghouse apparatus available for operation. Lightning, fire, flood and other accidents may cause failures, but the service engineer with a knowledge of the construction of the apparatus, its operating characteristics, the connections possible, and the adjustments necessary, will get it back into operation in the shortest possible time.

Foremost among the traditions of the Service Department is the protection of the reputation of Westinghouse Apparatus. This, of course, includes its design and its manufacture. When failures occur, operating conditions must be thoroughly investigated, and, if found to be at fault, the circumstances must be explained to the customer, but without giving offense. The Service Department traditions of effort and willingness to help in times of trouble may sometimes be the deciding factor when the purchase of new apparatus is being considered by an operating company.

DRAWING DIMENSIONS

Important dimensions are now usually indicated on all drawings, where formerly drawings were made to scale. This is an improvement over the cutting to fit method, which was sometimes annoying to the service engineers. It is still somewhat puzzling when the shorter space in an assembly has an indicated larger dimension. The erector cannot be certain that the figures are correct.

Do not make the erector add many small dimensions to obtain a single dimension that he requires. As examples: We know that the factory must have accurate lengths for all diameters of a large shaft. The erector may require the length from the end of the hub to the face of the coupling. It has been sometimes necessary to add many dimensions to obtain this, and then perhaps to subtract the distance from the center-line to the end of the hub. In a vertical waterwheel generator, it is essential for the erector to have the dimension from top of sole plates to face of coupling. Many additions and subtractions have sometimes been required to obtain this dimension.

WEIGHTS

The erector is always interested in the weights of the various parts of the apparatus that he is required to handle. The weight of a small part may be important if the part is missing and must be transported a considerable distance, possibly by express, by aeroplane or on the back of a mule.

Provision must be made for handling apparatus. Holes for lifting hooks or slings are required in large frames. Openings for jacks are sometimes desirable and shaft extensions may be necessary. Eye-bolt holes located in smaller parts may save much time and prevent accidents. Space to use wrenches must be allowed.

ASSEMBLY OF APPARATUS

Instructions concerning assembly of apparatus should appear on the assembly drawing that the erector will use, and not on the drawing showing a part of the apparatus. As an example: Instructions to use fishpaper in the "splits" of the stator core of large apparatus were for some time shown on the armature assembly drawings. This drawing is seldom used in the field as it shows only a sectional assembly of the stator punchings which are generally built up in the factory. These instructions now appear on the W. A. F. plan drawing which is essentially a field assembly drawing.

Instructions covering special methods of assembly are sometimes very necessary. Placing rotors in stators of large apparatus may be taken as an example.

Right angle "fits" are difficult under any condition, but they are particularly difficult when gaskets must be compressed at both surfaces. A turbine-generator end bell with gaskets that must be compressed about 1/8" at both the frame and the bedplate surfaces is an example.

SEQUENCE OF ASSEMBLY

What may be termed the "sequence of assembly" is also sometimes important. A design of induction regulator was manufactured in which the opening through the top, or connection end, of the stator coils was smaller than the diameter of the rotor. It was a simple matter to take this apparatus apart by lifting the stator over the rotor. But practice has been to take the rotor out through the stator and many of these regulators were damaged because no special instructions were given concerning this unusual assembly.

FITS AND TOLERANCES

Fits, clearances and tolerances required by the erector should be plainly indicated. It is hardly worthwhile to attempt to check the alignment of a shaft to .0005" if the exposed section that can be checked has a tolerance of .002".

MAGNETIC PULL

Years ago the unbalanced magnetic pull was indicated on the outline drawings covering most large rotating apparatus. This undoubtedly tended to prevent bearing troubles as the customer was warned concerning the tremendous forces resulting from an unequal air-gap.

CONNECTIONS

The correct connections for apparatus should be plainly indicated. "Connect leads 2 and 4 and 6 and 8 together" would have caused a serious wreck once if it had not been for the caution of the erector.

CROSS REFERENCE

Drawing cross references are very helpful to the service engineer. The stock order file is not sent to the district and it is seldom (except for very large installations) that a drawing list is given to the erector; it is very desirable, therefore, that the more important drawings, such as the general assembly and the W. A. F. refer to other drawings covering detail parts.

SUB-NUMBERS

Sub-number explanations should be explicit and sufficiently comprehensive to be understandable without additional information. The stock order on which the change applies may be very helpful to the Service Department. Stock orders are usually indicated on nameplates; D-Specs are not.

EXAMPLE OF SERVICE JOB

A typical service job would be: Apparatus that has been in service 10 years fails and emergency repairs are required. The district service office identifies the apparatus and telphones the headquarters office for drawings. When the drawings are received the service engineer finds that some of them were originally made 12 years before and that they bear fifteen sub-numbers, the last of which is dated 5 years before this failure occurred. Also, he finds that in essential details (some of which may have contributed to the failure) the apparatus is not like the drawing. Generally he does not know what sub-number applies to the particular apparatus involved, and it is certainly difficult to identify the changes covered by subsequent sub-numbers.

ALTERATIONS

Alterations are sometimes made in old apparatus that require changes in design and new drawings showing new parts to be used in connection with old parts which must be altered, possibly very little to secure the desire result. The old drawings are not changed, and the new detail drawing does not always indicate clearly the change to be made in the old part. Installing a new type thrust bearing support in an old type oil pot may be considered an example.

QUESTIONS

CONFERENCE ~~68~~ 69

MICARTA

1. Demonstration of Process

2. Classification of bases
   Paper
   Fabric
   Wood
   Asbestos

3. Mechanical properties
   Warpage
   Effects of Temperature
   " " partial machining

4. Electrical Properties
   Effect of humidity

5. Products
   Plates
   Tubes
   Angles and channels
   Decorative Micarta
   Helmets, etc.

Questions

CONFERENCE 7
CLERICAL ENGINEERING - ORDERS AND SPECIFICATIONS

Inquiry from Customer to District Office

1. The district sales office is provided with printed information regarding our apparatus. Upon receipt of an inquiry from the customer, he may be sent any of the following literature which applies: Price Forms, Catalogs, descriptive literature, etc.

2. The district Sales and Engineering Departments are provided with data which enable them to quote on customer requirements. This includes: district office engineering files, engineering data letters, A.C. motor performance data, control hand book, switchboard data, circuit breaker data, etc.

3. Inquiries are referred to Headquarters where the Engineering Department prepares partial or complete preliminary designs, cost data and performance data.

Negotiation Numbers:

For purposes of identification, a negotiation number is usually assigned to inquiries coming under #3.

Customer Specifications:

Customer specifications may be drawn up in such a way that standard apparatus will meet the customer's requirements, or the specification may call for special features which necessitate specially built apparatus.

Performance Specifications:

Performance specifications usually contain information as to rating, efficiency, insulation, test, dimensions, weight and description of apparatus.

Customer Contract:

The customer contract contains clauses covering the rating and performance, and the delivery date. It may also provide penalties for failure to deliver on time or for failure of apparatus to meet specifications.

General Order:

The general order is an itemized list of apparatus containing sufficient information regarding each item to enable the works to supply satisfactory equipment.

Manufacturing or Shop Order:

The shop order contains information covering a complete piece of apparatus, i.e., an item from the general order.

Electrical Specifications:

There is no definite dividing line between the mechanical part of apparatus and the electrical part, or between the design specification and the electrical specification. Broadly speaking, the electrical specification conveys direct to the shop, all manufacturing information that does not require mechanical drawings. It may contain information required by the Drawing Division and is therefore at all times available to draftsmen as auxiliary to the design specification.

Electrical specifications contain:

1. Name of apparatus
2. Complete electrical manufacturing information
3. Bill of material
4. First design number and first stock order number
5. Engineers' signatures with dates

Insulation Specifications:

Insulation specifications embody instructions: how to insulate the apparatus they cover, and what tests to make to ascertain if the apparatus is properly insulated.

Test Specifications:

Test Specifications are divided into three classes:

(a) Those covering complete engineering tests
(b) " " short " "
(c) " " commercial " "

The various tests made on apparatus by the Testing Department are made in accordance with the test specifications.

Design Specifications:

A design specification conveys to the Drawing Division and the Manufacturing Information Engineering Department, complete instructions for making drawings; for the transmission of information on drawings, and for complete indexing of the specification itself. It is not available to the shop either as direct instructions or for reference.

Design specifications embody the following information:

1. Name of apparatus
2. Relation to existing apparatus
3. Suggestions as to tools, etc.
4. Nameplate number (or lettering on apparatus)
5. Service conditions
6. First customer
7. Engineering department references
8. First L number, first shop order number or expense order number and what the specification supersedes
9. Total pages in the specification
10. Signature of the Manufacturing Information Department

Manufacturing Drawings:

The standard book describes the drawing room system and contains the information necessary for the preparation of all drawings, drawing lists, records, etc.

Whenever it is possible, without undue complication, to use an old drawing by adding new items, this is done. This applies particularly to tabulated drawings. Requests for changes on drawings must bear the approval of the section engineer.

Variations of the system depending upon local conditions are used in different departments at East Pittsburgh as well as in the different works of the organization.

Drawing Lists:

The drawing list is an official connecting link between the design specification, the drawing and the information used by the shop. It carries the design specification number with all the sub-letters. It contains:

1. The name of the apparatus
2. Title of Drawings
3. Drawing numbers
4. Complete list of items or style numbers required from drawings
5. First shop order number
6. Identifying data

Manufacturing Information:

When the Manufacturing Information Engineering Section receives a shop order from the design engineer, it contains what is known as engineer's information which in general contains a design specification number, an electrical specification number, diagram and outline drawings and any special instructions or information which the engineer desires to have transmitted to the factory.

From this shop order, the manufacturing information engineers write the complete instructions necessary to manufacture the apparatus

Fabrication of Parts:

The separate items that go to make up the complete apparatus are usually fabricated in the feeder sections.

Certain items, such as hardware are purchased from outside manufacturers. Standard articles regularly carried in stock, such as bolts, nuts, etc., are ordered directly from the storerooms.

Assembly:

When the necessary parts have been completed, they are sent to the assembly section, where the parts are assembled into the completed apparatus.

Inspection:

Inspection includes quality and quantity inspection of parts at every stage of manufacture as well as the completed apparatus.

Tests:

Tests of parts such as coils, are made in the feeder sections where the parts are manufactured, but the final test of completed apparatus is made in the Testing Department, in accordance with the test specifications.

Shipping:

After the finish is applied and the final inspection made, the apparatus is ready for shipment to stock or to the customer.

Supervision of Erection:

It is the function of the Service Department to install, or to supervise the installation of certain classes of equipment, especially large, complicated, or high voltage apparatus.

QUESTIONS:

CONFERENCE 8

CLERICAL ENGINEERING-SHOP ORDERS

Shop orders are entered for items on general orders, interworks requisitions, and meter-transformer requisitions when the required material is not stock apparatus.

SHOP ORDERS
INFORMATION WRITER

This class of orders calls for non-stock standard or slightly off-standard apparatus and are handled by an order service engineer.

SHOP ORDERS
SPECIAL APPARATUS

Orders for special apparatus are handled by the design engineer and may or may not necessitate new drawings.

SUB-SHOP ORDERS

Orders of this class are employed where a customer requisitions on one order, apparatus or equipment for two or more stations.

SIDE-SHOP ORDERS

Orders of this kind are, as a rule, entered by an engineer who requires, along with apparatus designed in his department, parts or auxiliary apparatus designed in another engineering department.

L. & M. SHOP ORDERS

These orders are entered for labor and material necessary to change over stock apparatus to fill an order.

MANUFACTURING INFORMATION
PROCEDURE IN RELATION TO
SHOP ORDERS

After the order service engineer or the design engineer designate on the shop order reading, the particular specifications that are to be used, the shop orders are transmitted to the Manufacturing Information Division, Clerical Engineering Department.

The shop order numbers are recorded and the orders assigned to information interpreters or formulators who requisition all material and parts which are required to completely manufacture the apparatus.

ENGINEERING SHOP ORDERS FILED

A copy of each page of material lists and component part lists, are filed in the shop order cover in the Engineering Department for purpose of reference in case a duplicate order is received or renewal parts requisitioned.

DISTRIBUTION OF MANU-
FACTURING INFORMATION

All requisitions ordering material, parts or complete apparatus are assorted according to sections and are delivered by messenger five times daily.

Conference 9

PRODUCTION SYSTEM - FUNCTION - ORGANIZATION - METHODS

The Planning or Production Department is the department usually responsible for control of production in a manufacturing plant. Production must be under a strict control so that the required product shall be produced by the best and cheapest methods, be of the required quality and produced at the required time.

Expansion of manufacturing facilities and increasing emphasis on prompt delivery necessitates a Production Department.

The divisional responsibilities of the Production Department are:

(1) The order

(2) Planning, scheduling, and executing the order

(3) Routing and layout for stock

(4) Stores

(5) Shipping

(6) Information system and co-responsibilities with engineering, accounting, and other divisions of management.

When an order is received in the shop, the first thing is to set a delivery date. This date is usually set by negotiation or schedule although it usually means that the date is set by the Sales Department who know best when the product is required by the customer. It is not always possible for the shop to meet this date. In such cases, the shop gives the best possible date, reporting it to the Sales Department. Sometimes overtime and other emergency measures may be authorized to shorten the time required to complete. The time required to secure materials and fabricate them determines the possible delivery date.

After the date is set, a date is established for all parts of the apparatus in line with the completion date and then followed through to insure that these dates are met. Improper scheduling results in:

(1) Congestion of shop due to unmatched parts

(2) High Inventories

(3) Disorderly manufacturing

(4) Failure to meet dates

(5) Excessive costs due to extra set ups.

A schedule is made by a man in each division with training and experience and a knowledge of the time required to secure materials, time required to fabricate and assemble materials, and the order of processes. Working back from the required completion date, he establishes dates from the sub or component parts down to the individual parts. He then distributes orders for these parts to the various shop sections as designated by the Routing Department. Each section in the shop maintains a schedule or diary of each day's due requirements. The production man is responsible for dispatching and putting on the due dates. Sometimes it is not possible to complete on these dates for various reasons:

(1) Material stock out or must be purchased

(2) Date is impossible

(3) Tool breakage or machine breakage

(4) Changes in requirement

(5) Errors

In case of delay it is the duty of the production man to minimize the effects of these obstacles. In the case of (2) the customer should be notified of the best date possible. In the other cases substitutes should be suggested or other means found to produce and all effort exercised to recover as much of the lost time as possible.

It should be borne in mind that while true planning aims to prevent these difficulties, yet a large part of the job consists in taking proper measures when they do occur.

Upon receipt of an order, the following factors in planning must be determined:

(1) What work shall be done

(2) How it shall be done

(3) Where it shall be done

(4) When it shall be done

The Sales and Engineering Departments by means of manufacturing information specify what shall be done. How and where it shall be done is determined by:

(1) Routing to correct division by the Routing Department

(2) Layout of operations by the Time Study Department

When it shall be done is the schedule planned and executed by the Production Department.

By dispatch work is meant the assignment of jobs to certain machines and workmen in the order desired. The requirements of an efficient dispatcher are:

(1) He must know the capacities of the machines and processes

(2) He must know the capacities of the various workmen

(3) He must be able to plan work in advance in orderly fashion

(4) He must have the confidence of the workmen and the supervisors

Some of the duties of the dispatcher are:

(1) To draw in the material required for the workmen

(2) Supply the drawings and tools

(3) Assign the jobs and arrange movement between operations

(4) Supply the necessary working cards and tags

A continuous process industry is one where raw materials enter one end of the factory and go through it in a steady stream.

An intermittent process industry is one where the parts do not move automatically from machine to machine but must be moved as occasion requires.

The latter is sometimes modified by the intermittent lot type. This means that where the product is special but can be applied to several customers' requirements, parts are carried through the shop in lots in anticipation of sales. Quantities are determined by the market demand.

Lot intermittent type conditions approach those of the special order industry when a variety of products is involved and manufacturing orders for each kind are infrequent.

Production control in a continuous process industry is comparatively simple because the path or route that the material is to follow is fixed by the sequences of processes and the times of operation are fixed by the capacities of the machines and processes.

Production control in intermittent process industries is more difficult since the required product is made to a customer's special order and the repetition of such orders is unusual. The parts may follow no route through the shop and the times required for each operation are not usually known in advance.

More supervision is required in an intermittent process industry to prevent congested conditions in the shop caused by overloading of some machines and underloading of others.

The production man is not through with his order until he makes final delivery of the apparatus to the Shipping Department with the proper clearing papers.

CONFERENCE 10

PRODUCTION SYSTEM (CONTINUED)

PATTERN RECORD

The Pattern Record Department check and order the necessary Patterns. They maintain records of available patterns and their location if in outside foundries.

TOOL RECORD

The Tool Record Department maintains files of all usable tools and where they are located. They also check and order the necessary tools.

STOCK LAYOUT AND ROUTING

The Stock Layout and Routing Department determines the desirability of stocking apparatus and material based on activity records. They determine the place of manufacture based upon manufacturing facilities, costs, shop layouts, etc.

STOCK CONTROL

This activity has to do with the control of stocks of finished apparatus in the plants and district warehouses.

DRAFTSMAN CAN HELP BY

Using existing patterns wherever possible
Using existing tools from information obtained from tool reference drawing
If special processes are to be used, by making the drawing reference unmistakably clear to prevent any chance of error.

QUESTIONS:

CONFERENCE 11
STORES AND MATERIAL CONSERVATION

STORES

Function:

The function of the Stores Department is to see that the proper quantity of material is available when needed.

Organization:

Storerooms - Are located at strategic points throughout the works.

Records - Complete ledger records are kept so that the required quantities of items will be maintained and so that adequate records are available to forecast future demands.

Inspection - Inspection of incoming materials is made to assure that they comply with Company specifications and drawings.

MATERIALS

Stocking:

Raw Materials - Stocking of raw materials is authorized through Form 4504.

Completed Apparatus - Stocking of completed apparatus is authorized by the Sales Department through the Stock Control.

Elements - Stocking of elements is authorized by the engineers in conjunction with Stock Layout & Routing Department.

Withdrawals:

Raw Material - Is withdrawn only on requisition and withdrawals are entered directly on ledgers.

Parts - Are withdrawn only on requisition. A bin card carries a record of the amount in stock. Withdrawals are entered at once on bin card and new entry made of the amount in stock. When the amount in stock reaches the ordering point, the bin card is sent to the Storekeeper who then takes the necessary steps to replenish the stock.

Proper care of stocks depend upon the materials involved and housing and storage facilities are in accordance with the nature of the material.

MATERIAL CONSERVATION

Inactive Materials:

Inactive materials result primarily through changes in design or changes asked for by customer.

Disposition:

Inactive materials may be used with modification where economical. Other methods of disposition are - salvaging by selling or scrapping.

DRAFTSMAN CAN HELP BY

Using stock materials wherever possible
Arranging design to keep scrap at a minimum

QUESTIONS:

CONFERENCE 12

PURCHASING

FUNCTION:

The function of the Purchasing Department is to buy to the best advantage all materials and equipment needed for the conduct of the business of the Company. Buying to the best advantage includes:

1. Buying proper products for purposes required.
2. Getting material in the plant at the time required.
3. Buying in the proper quantity.
4. Buying at the right price.

ORGANIZATION:

1 - Management:

(a) Formulate and supervise policies and system.

2 - Buyers: Specialists who
(a) Develop sources of supply.
(b) Interview salesmen.
(c) Negotiate contracts and prices.
(d) Place orders.

3 - Clerical:
(a) Follow up for deliveries
(b) Check invoices for prices and terms.
(c) Maintain price and purchase records.
(d) Information division.
(e) Catalog and commodity information records.

4 - Inspection:
(a) Handle complaints on material quality.
(b) Handle adjustments on defective material.
(c) Handle mill inspection.
(d) Handle test reports on material purchased.

5 - Miscellaneous:
(a) Market studies.
(b) Scrap sales.
(c) Specifications.

SPECIFICATIONS:

Purchasing Department specifications are prepared by the Engineering Department with the assistance of the Purchasing Department. These enable the Purchasing Department to maintain a certain standard of quality in accordance with Company requirements.

REQUISITIONS:

Since the total cost of material purchased runs into large figures, it is essential that proper requisitioning methods be employed.

THE DRAFTSMAN CAN HELP BY:

1. Properly and fully identifying all material on drawings.

2. Consulting Standard Book and using standard designations only.

3. Consulting Standard Book and using standard stock materials as against special "non-stock" materials. Use of standard stock materials saves money by,-

   (a) Eliminating expense of ordering the special material.
   (b) Eliminating delay in waiting for the special material.
   (c) Savings resulting from quantity purchases of stock material.

4. Consulting latest catalogs for special materials.

5. Consulting Purchasing and Material and Process Engineering Departments when special materials are required.

6. Making use of the available set-up of Style Numbers and "M" numbers to cover designation of special "Bought Outside" specialties such as gears, switches, resistors, etc., in preference to showing catalog numbers and suppliers names on tracings.

7. Arranging "Bought Outside" parts on separate drawings so that suppliers may exactly determine our requirements.

QUESTIONS:

CONFERENCE 13

INTRODUCTORY TALK ON MATERIALS

Selection of Materials

The first thing to note in selecting materials is the relation of material to limits in design; our designs are limited by the materials available. In general we have a fairly wide choice; for instance, alloy steel, wrought iron, cast steel, etc. The kind selected depends upon the characteristics of the material and the job to be done.

A conductor, for instance, should have low resistance; therefore, we choose a material that has high conductivity, usually copper. Silver is better, but for obvious reasons is not used. Cost as well as other elements must be considered.

Aluminum is extensively used, but is not as good a conductor as copper. Copper occupies only 60% of the space of aluminum; on the other hand, aluminum has the advantage of lightness.

Among insulating materials, mica, for instance, has high insulating properties and will retain these properties under fairly high operating temperatures at which most others deteriorate rapidly.

At times there is a tendency for the draftsman to design apparatus around a "wish". Pre-knowledge of what materials are obtainable is of considerable advantage. One essential reason for selecting the right materials is that of economy. The cost of materials is important; it is easier to save money in the use of materials than in the methods of manufacture.

One of the problems of the draftsman is how to do the job adequately and at the lowest cost. This involves careful study of size as well as quality. Some cheaper materials are not much better than fillers, therefore, it is necessary that the draftsman know which materials will stand up under stress. Knowledge of how poor materials and how good materials affect the finished product is important.

"You get what you pay for," is a frequent expression, but not always true. By best we may mean the best for our purpose; therefore, we must consider the problem of using material which is most suitable for the service required and its probable life.

Copper alloy which has a very closely controlled resistance is used for damper-bars, etc., cut costs six cents a pound more than a similar alloy not having special resistance properties. It was found that this material was being used for other parts where a cheaper metal would serve the purpose just as well.

Another example is that of cotton tape for coils. We formerly used a tape with a fine weave, but upon trying a coarser thread we found that we got equally good results. The change to this coarser type of thread saved $12,000 in one year.

Percentage of Cost of Material to Total Cost of Products

Data 1931

DIVISION OF FACTORY COST BY PERCENTAGE

Plant	Labor	Expense	Material	Product
Newark	30	34	36	Instruments
Attica	29.5	29	41.5	Stokers
East Pittsburgh	24.1	30	45.9	Heavy machinery
East Springfield	22.9	32.5	44.6	Small machinery
S. Philadelphia	20.6	35	44.4	Turbines and steam equipment
Cleveland and St. Louis	18.8	27.3	53.9	Lighting Equipment
Nuttall	18.5	30.5	51	Gears
Mansfield	18.2	24.4	57.4	Appliances
Homewood	16.6	24.4	59	Coils and replacement parts
Derry and Emeryville	16.2	27.9	55.9	Porcelain
Sharon	14.6	20.6	64.8	Transformers
Emeryville-Electrical	9.8	14.4	75.8	Assembly plant transformers
All Works	21.9	27.1	51	

Variety of Materials

We use about 3856 kinds of raw materials. In East Pittsburgh alone we carry in stock about 500. We use 56 kinds of asbestos, 104 kinds of bar steel, 49 kinds of lubricating oil, besides other oils such as castor, linseed, etc., 87 kinds of cement, 11 kinds of copper sheet, 22 kinds of cotton cloth, 3 kinds of diamonds, 29 kinds of dyes, 83 varieties of enamel, 53 kinds of paint, 142 varieties of paper, and 37 varieties of shellac.

How Much Do We Purchase?

In 1935, which was a pretty fair year, we purchased thirty million dollars worth of raw materials, one third of which was bought by the East Pittsburgh Works. Some of the more important items are:

East Pittsburgh

Material	1935
Copper products	$2,400,000
Electrical sheet steel	900,000
Steel and Iron	2,560,000
Insulating Materials	1,275,000
Finishing Materials	220,000
Lumber and Packing	275,000
Miscellaneous	770,000

From the above it will be seen that the selection of the proper materials that go into our designs is very important as a money saving factor.

QUESTIONS:

CONFERENCE 14

MATERIALS

Classification of material used for electrical apparatus

A. Four classes of materials used according to function

1. Mechanical material
2. Conducting material
3. Insulating material
4. Magnetic material

B. Difference between conductor and insulator

1. Conductor, a material intended to carry a current. Insulator, intended to restrict the flow of current.

C. Insulating Materials

1. Insulating materials are made largely of organic material and have their origin in animal or vegetable substances. Insulating materials have very serious handicaps which have to be overcome.

2. General classification

a. Solids
b. Plastics
c. Liquids
d. Gases

Solids
1. Natural -- example - marble
2. Vitreous-- " - glass
3. Fibrous-- " - cotton
4. Rubber-- " - rubber substitute
 a. duprene
 b. thiokol

Plastics
1. Synthetic resins-- example - bakelite
2. Waxes-- " - paraffin
3. Gums-- " - asphalt

Liquids
1. Natural oils--example - linseed oil
2. Mineral oils-- " - petroleum
3. Varnishes
4. Solvents-- " - benzine

Gases
1. Air
2. Hydrogen
3. Nitrogen
4. Carbon Dioxide

D. Magnetic Materials

1. Two classes

    a. Permanent magnet
    b. Electro magnet

    Four qualities of steel laminations.
    Proper choice important

E. Structural Parts

a. Ferrous--steel and steel alloys--many new materials now
b. Non-ferrous--useful copper and aluminum alloys.

F. Finishes

1. Fast drying paint now used. Formerly it required several days to dry paint. Modern finishes now available, give fair protection in one coat or excellent durability in three coats of paint adapted to fast production methods.

QUESTIONS:

CONFERENCE 15

CONDUCTORS

A substance in which a flow of electricity occurs is called an electric conductor. Every substance is a conductor of electricity, at least to a slight extent, but some materials are far better than others. A material which permits only a relatively small amount of flow of electricity is called an insulator. Those materials which permit a relatively large flow are known as conductors.

Metals are the best conductors. Carbon, graphite, and most moist substances are fair conductors. Dry, non-metallic bodies such as air, hydrogen, nitrogen, porcelain, glass, oil, rubber and dry paper are classed as very good insulators.

Conductors used for transmission of electric energy-

Copper
Aluminum

Conductors used for breaking electrical circuits-

Copper
Silver
Platinum - Iridium
Platinum - Ruthenium
Tungsten
Silver Nickel
Silver Molybdenum
Silver Graphite
Copper Graphite
Nickel
Carbon
Graphite

Conductors used for resistance and heating-

Copper Nickel
Nickel Chromium
Cast Iron
Cast Iron 2% Ni
Carbon
  (Variable)
  (Fixed)
Nickel Steel
Salt Water

Formula No. 1

Diameter of standard rope or concentric stranded cable:

$D = d \times k$

Where:

D = Diameter of Strand (inches)
d = Diameter of individual wires (inches)
k = Factor (see below)

Factors for various standard strandings:

Concentric Strand:

No. of Wires	k
7	3
19	5
37	7
61	9
91	11
127	13
169	15
217	17
271	19

Rope Strand:

No. of Wires		k
49	(7 x 7)	9
133	(19 x 7)	15
259	(37 x 7)	21
343	(7 x 7 x 7)	27
361	(19 x 19)	25
427	(61 x 7)	27
703	(37 x 19)	35
889	(127 x 7)	39
931	(19 x 7 x 7)	45

Example:

What is the diameter over a stranding 19 - .102"?

$$D = d \times k$$
$$= .102 \times 5$$
$$= .510 \text{ inch}$$

What is the diameter over a stranding 931 - .005"?

$$D = d \times k$$
$$= .005 \times 45$$
$$= .225 \text{ inch}$$

Formula No. 2

Weight of a solid copper wire:

$$W = d^2 \times .003027$$

Where:

W = Weight in lbs. per 1000 ft.
d = Diameter of wire in mils (.001 inches)

Example:

What is the weight of a copper wire .010 inch in diameter:

Note: .010 inch = 10 mils.

$$W = d^2 \times .003027$$
$$= 10^2 \times .003027$$
$$= 100 \times .003027$$
$$= .3027 \text{ lbs. per 1000 ft.}$$

Formula No. 3

Diameter of a cable of n number of wires:

$$D; 1.155\, d\sqrt{n}$$

Where:

D = Diameter of cable (inches)
d = Diameter of wire (inches)
n = Number of wires

Note: This formula gives only approximate results.

Example:

What is the diameter of a cable consisting of 144 wires each .010 inch in diameter?

$$D = 1.155\, d\sqrt{n}$$
$$= 1.155 \quad .010 \quad \sqrt{144}$$
$$= 1.155 \quad .010 \quad 12$$
$$= .1386 \text{ inches}$$

Formula No. 4

Weight of a stranded bare cable:

$$W = w \times n \times 1.02$$

Where:

W = Weight of cable in lbs. per 1000 ft.
w = Weight of individual wires in lbs. per 1000 ft.
n = Number of wires in the cable

Example:

What is the weight of a cable consisting of 144 wires each .010 inch in diameter?

$$W = w \times n \times 1.02$$
$$= .3027 \times 144 \times 1.02$$
$$= 44.46 \text{ lbs. per 1000 ft.}$$

Formula No. 5

The area of a solid copper wire in circular mils equals the diameter of the wire (in mils) squared.

Example:

What is the area in circular mils of a wire .100 inch in diameter?

Note: .100 inch = 100 mils

100 x 100 = 10,000 circular mils

Formula No. 6

The area of a solid copper wire in square mils equals the diameter of the wire (in mils) squared times 0.7854.

Example:

What is the area in square mils of a wire .100 inch in diameter?

Note: .100 inch = 100 mils

100 x 100 x .7854 = 7,854 square mils

Formula No. 7

Resistance of Wire:

$$\text{Resistance per foot} = \frac{\text{Resistance per circular mil foot}}{\text{Area in circular mils}}$$

$$\text{Resistance per foot} = \frac{\text{Resistance per square mil foot}}{\text{Area in square mils}}$$

Example:

What is the resistance per foot of wire .010 inch in diameter which has a specific resistance of 650 ohms per circular mil foot?

$$\text{Resistance per foot} = \frac{650}{100}$$

$$= 6.5 \text{ ohms}$$

Example:

What is the resistance per foot of wire .010 inch in diameter which has a specific resistance of 500 ohms per square mil foot?

$$\text{Resistance per foot} = \frac{500}{78.5}$$

$$= 6.369 \text{ ohms}$$

Standard Sheet References

S781
S782
S793
S996.1
S896.5

CONFERENCE 16

MATERIALS - INSULATION

Insulating materials are those used for separate parts of electrical apparatus to confine the current to certain paths. All materials conduct electricity to some degree; those which conduct it in very minute quantity, usually so small as to be difficult to measure, are termed insulating materials. Their property then is a very high resistance.

They are classified depending on the physical form as:

solid		Class A (organic)
liquid	or as	Class B (inorganic)
gas		etc.

In general, organic materials will not last if subjected to more than 100°C. temperature when exposed to the air, or 125°C if thoroughly protected against oxidation. The inorganic materials stand much higher temperatures,-mica, being satisfactorily used at 600 or 700°C. Asbestos begins to break down between 500 and 600°C. but can be safely used at any lower temperature.

Materials most commonly used are:

Porcelain: A combination of clays and fluxing materials baked at a very high temperature. Usually made up by two different processes,- In the wet process the mixture of clays is worked into form by molds or by other form process and carefully dried and fired.

In the dry process, the clay is dried so that it can be worked up into small pellet forms then placed into forms and pressed.

The latter process gives a more porous type of porcelain than the wet process and is therefore used only on low voltage applications.

Mica: Found in nature in a form which can be split into very thin leaves or splittings. Splittings range in area from one square inch to several square inches and are usually from .0005" to .0015" thick. They are built up into plates or sheets by using an adhesive binder and laying the splittings one on the other, held together with the binder. The splittings themselves have a dielectric breakdown of approximately 750 volts per mil, but the built-up sheets seldom run higher than 500 volts per mil. Sheets may be solid like heater or commutator segment mica, flexible like materials used on coils, or capable of being softened by heat, such as used for Vee rings.

Asbestos: Always comes as a loose fibre which is obtained by crushing a certain type of crystalline rock, usually filled with impurities of a conducting nature. Spun or woven into shape, or may be run over paper mill to make an asbestos paper usually bound together by starch. In itself it is not a very good insulator but is a good spacer and can stand high temperature. It is usually filled with varnish when used as insulation.

Papers: Made in various ways:

From linen (very high grade, very clean, used in making condensers)
" cotton(also clean, which makes a strong insulating material into which varnish enters readily)
" wood pulp (which is fairly strong, but may contain resins preventing absorption of varnishes)
" rope (which makes the strongest papers but is apt to contain metal particles).

Cotton: Almost universally used for cloth which is treated with varnish either before or after being applied to a coil. Pretreated cloths come in tan or black color, made with a clear or black varnish. In general the black cloths have higher dielectric than the tan. See Standard Book, Page 776.5.

Rubber: Limited as an insulating material because it gets hard and brittle at usual machine temperatures. Large quantities used as insulation on cables. Has a high dielectric but is affected by oil.

Plastics: Molded products are good insulators and make good supports. Highest grades made of bakelite and a filler, such as ground wood and asbestos fibre. Use of molded products are limited because of the expense of material and molds in which they are made.

Liquids: Varnish is included in this class although it is not a liquid when in final form for use, having been dried down into a solid film. It has high dielectric but the film must always be supported either by being applied to cotton or asbestos or some metal. When used to impregnate a coil, important differences are found in the way in which they dry inside the coil and their flexibility afte being dried. It is desirable to have a varnish which will dry completely throughout the coil, but this is hard to obtain and is usually very expensive.

A true liquid insulation is the mineral oil used in circuit breakers and transformers. These mineral oils have a definite fire hazard, however, and for certain applications are replaced by fireproof liquids, usually chlorinated material.

Gases: Seldom used as a recognized insulator except the air space between conductors. Does not have a very high insulating value but can be used to advantage if space permits.

QUESTIONS:

Reference F-4552-D

CONFERENCE 17

MATERIALS - MAGNETIC

1. Ferro Magnetic Materials. Iron, Nickel, Cobalt.

2. Electro-Dynamic Machine.

    Generator - Fundamental principle.

    Use of magnetic material - Perm. 100 to 20,000.
    Eddy losses - Use of thin material.
    - High resistivity desirable.
    Hysteresis loss.
    Use of plain iron.
    Use of silicon iron.
    Aging effect.

    4 Grades in use - Losses 1 to 5 ratio.

3. Magnetic Circuit of Transformer
    Simple -
    Losses important - continuous.
    High Grade Material.

4. Magnetic Circuit - Generator
    Armature.
    Poles and frame.
    Leakage - More complex.
    High and medium grade.

5. Motors -
    Intermittent to continuous.
    Medium and low grade.

6. Contactors, relays, instruments.
    Variable conditions
    Medium and high grade
    Special use of hipernik.

7. Electrical Steel Sheet and Strip.
    How made.
    Quantities used.

8. Permanent Magnet Steels.
    Nature of material.
    How made and used.

9. Non-Magnetic Steels.
    How made and used.

Refer to
Standard Sheets
S - 834
875
915.1
915.2
915.4
921
927
929
939
945.1
945.2
957.8

QUESTIONS:

CONFERENCE 18

MATERIALS - IRON & STEEL

Heat Treatment

1. Micro-structure
   Shows the nature or structure of crystals
   (a) Grain size
       How it affects properties
   (b) Carbon forms
       As soft graphite in cast iron
       Hard iron-carbide in steels
   (c) Impurities
       May be found as slag fibres (rolled or forged products)
       Globules (cast products)
       Solution in iron

2. Iron-Carbon Diagram
   Explains the structure of steels obtained by heating and cooling

3. Effect of cooling rate
   Furnace cooling (annealing)
   Air cooling (normalizing)
   Oil quenching
   Water quenching
   Brine quenching

Questions

CONFERENCE 19

MATERIALS - IRON & STEEL

Properties and Specific Materials

1. General type of properties.
   Hardness
   Tensile strength
   Endurance limit (fatigue)
   Yield point and elastic limit
   Ductility
   Toughness (impact strength)
   Corrosion and oxidation resistance
   Weldability

   Questions

CONFERENCE 20

PROPERTIES OF MATERIALS

Forgings, Castings, and Rolled Products

(a) Soft materials
    Ingot iron
    Low carbon steels
    Wrought iron
    Cast iron
    Malleable iron

(b) Moderately hard heat treated constructional materials

    Effects of carbon content
    Alloys
    Heat treatment
    Medium carbon
    S.A.E. steels

(c) Hard Tool Steels
    Effect of alloys on heat treatment and hardness
    Cutting tools
    Die steels

(d) Case hardened steels

REFER TO STANDARD SHEETS

S834
S875
S915.1
S915.2
S915.3
S915.4
S921
S927
S929
S939
S945.1
S945.2
S957.8
S507
Photostat Equilibrium Diagram

QUESTIONS:

CONFERENCE 21

MATERIALS

I Copper Alloys

A Brasses and Bronzes

1. Raw materials
2. Composition of Brasses and Bronzes
3. Melting Equipment and Practice
4. Impurities
5. Secondary or Scrap Materials

B Special Copper Alloys

C Physical Properties and Heat Treatment

D Applications - Cast and Wrought

II. Bearing Alloys

A Characteristics of a good bearing metal

B Types of bearing alloys

C Applications

QUESTIONS:

CONFERENCE 22

Materials -- Aluminum Alloys, Die Castings & Solders

A. Aluminum Alloys

1. Production of Metallic Aluminum
   Electrolytic Cell.

2. Sand Cast & Wrought

3. Applications

4. Heat Treatment & Physical Properties

5. Corrosion Resistance

B. Die Castings

1. Aluminum Base

2. Zinc Base

3. Bronze

C. Solders

1. Lead tin

2. Silver

3. Aluminum

Questions:

CONFERENCE 23

HARDWARE

Parts in general use - widely manufactured.
Each trade has its own line of hardware.

Former Conditions - Lack of standards and consequent lack of general use.

Example: Threads 1/2-12 vs. 1/2-13
Thread fits (fire-hose couplings)
War material experience
Electrical fittings

Present situation - Work of American Standards Association (ASA)

Example: ASA work on bolt and nut proportions.
ASA work on thread tolerances.

Results - Affecting supplier -
Heavier production in fewer lines
Better control
More development

Example: Manufacture of bolts

Affecting user -
Certainty of interchangeability
Lower prices
Better parts

Examples of Parts - Ball-bearings, lock-washers, screws, pipe fittings, rivets, bolts, nuts.

Draftsman helps by - Using standard parts shown in Standards Book.

Using parts needing standard tools, etc. for manufacture.

Penalty in using Non-Standard Parts -

Increased cost, slower deliveries, customer difficulty, etc.

Questions:

CONFERENCE 24

Finishes - Metallic

(a) Appearance

(b) Protection

I The mechanism and types of corrosion

It is estimated that 3-1/2 billions of dollars are lost each year by corrosion of metals.

Corrosion of metals may occur in two ways: (1) by direct chemical attack from gases such as hydrogen sulphide. (2) by electro-chemical action. Ability of metal to resist electro-chemical corrosion, or to protect any other metal from corrosion is indicated by its position in the electro-chemical series. Metals highest in the series possess the greatest tendency to corrode, and for this reason protect metals lower in the series when in intimate comtact. Thus, a zinc coating protects iron against rusting. When zinc-coated iron is exposed to the atmosphere a slight galvanic action is set up between the zinc and iron, and the zinc suffers corrosion, protecting the copper.

This condition takes place regardless of the thickness of the coating. The advantage of a heavier coating is that it lasts longer, but under ordinary atmospheric conditions where a slight amount of moisture is the only exciting liquid, the galvanic action is quite small, and the protective coating may last for several years.

Coatings that are below the base metal in the electro-chemical series, such as lead or tin or iron, simply act as a covering like a paint or varnish. If the coating is not complete, portions of the base metal that are exposed will corrode.

ELECTRO-CHEMICAL SERIES FOR PROTECTIVE COATINGS

Any metal in this list protects other metals lower in the list

ZINC
CHROMIUM
CADMIUM
IRON
NICKEL
TIN
LEAD
COPPER
SILVER
GOLD

II Cleaning

Good adhesion of a metallic coating requires thorough cleaning of the base metal surfaces before coating. To remove scale from hot pressed steel, a hot 10 per cent solution of sulphuric acid is used, but this cleaning operation may cause trouble, due to hydrogen embrittlement. This condition is reduced to a minimum by using an inhibitor in the acid solution. The function of the inhibitor, the composition of which is usually kept secret, is to keep the evolution of hydrogen to a minimum. For parts that have absorbed hydrogen, brittleness can be reduced by heating or boiling the parts in water for several hours.

To remove sand from iron and steel castings, immerse a hot 10 per cent solution of hydrofluoric acid for 20 to 30 minutes then wash parts in hot water.

To remove dirt and grease from brass, bronze and copper, immerse parts in a hot alkaline cleaning solution, made up of 6 oz. of cleaner to one gal. of water. Then dip parts in a solution of 1 part nitric acid and 1 part sulphuric acid and rinse in water, repeating the dipping until a bright appearance is obtained.

Dirt and grease are best removed from zinc and aluminum die castings by washing with an organic solvent such as carbon tetrachloride. Parts are then etched in a mixture of nickel chloride and hydrochloric acid or manganous sulphate and hydrochloric acid depending upon the type of alloy being plated.

II

PROTECTIVE METAL COATINGS FOR IRON AND STEEL

TYPE OF COATING	NOMINAL THICKNESS	PROTECTS AGAINST	APPEARANCE	COST (Cents per pound)	TYPICAL APPLICATIONS
Copper--electroplated	0.001 to 0.003	Indoor exposure	Un-polished Polished	4 20	To color small parts
Nickel--electroplated	0.0005 to 0.001	Weather Organic acids	Un-polished Polished	4 35	Small parts, control handles, scale plates
Chromium--electroplated over nickel	0.00005 to 0.0001	Outdoor exposure Wear resistant	Good	high	Control handles, hardware
Cadmium--electroplated	0.0005 to 0.003	Weather Marine exposure (not organic acid vapors)	Dull white	4	Hardware Mechanical parts
Zinc--sherardized	0.004 to 0.005	High temperatures	Rough Gray	2	Cast iron grids relay parts
Zinc--galvanized	0.004 to 0.005	Industrial atmospheres (not recommended for marine service)	Fair	3	Line material structural parts
Aluminum--calorized	0.005 to 0.010	High temperature	Rough gray	--	Hardware

PROTECTIVE METAL COATINGS FOR COPPER, BRASS AND BRONZE					
TYPE OF COATING	NOMINAL THICKNESS	PROTECTS AGAINST	APPEARANCE	COST (Cents per pound)	TYPICAL APPLICATIONS
Nickel--electroplated	0.0005 to 0.001	Organic Acids	Un-polished	4	Small parts
			Polished	35	Screws, dial plates
Cadmium--electroplated	0.0005 to 0.003	Marine exposure	Dull white	4	Brass hardware
Chromium--electroplated over nickel	0.00005 to 0.0001	Weather	Bright	high	Brass hardware Misc. parts
Silver--electroplated	0.0005 to 0.00175	Industrial atmosphere	Smooth white	35	Studs and contacts
Tin--electroplated	0.0005 to 0.001	Hydrogen sulphide	Smooth white	4	Small copper parts Food containers
Tin--tartar process	0.00002 to 0.00003	Coating not durable	Smooth white	4	To color copper and brass hardware
Tin-Lead hot dip	0.0003 to 0.0004	Sulphuric acid, industrial gases	Rough, white	4	Copper connectors, contacts, shunts

CONFERENCE #25

FINISHES-METALLIC (CONT'D.)

I METHOD OF APPLYING FINISHES

a. Iron-Steel

Protective coatings for iron and steel parts may be applied by dipping the parts into molten metal or by electroplating. Hot dipping or galvanizing process of applying zinc is oldest of present day commercial finishes, and is widely used. After work to be galvanized has been thoroughly cleaned, it is fluxed by immersing in a mixture of one part hydrochloric acid and four parts water and then dried at about 212 deg. F. (100 deg. C.). This drying operation must be complete, for if the work is not perfectly dry it may cause an explosion when it is immersed in the molten metal. The temperature at which the molten zinc is held depends somewhat on the size of the articles to be galvanized. For small work dipped by hand, temperature should be between 810 and 850 deg. F. (450-480 deg. C.).

Excess zinc can be thrown off by centrifugal force after parts are removed from galvanizing bath. This process is machine galvanizing, and is especially useful in throwing off excess zinc in galvanizing small threaded parts such as nuts and bolts. However, threaded parts must be machined with an allowance of 0.004 to 0.008 in. for the thickness of the zinc coating.

Sherardizing is another process of applying a coating of zinc to articles of iron and steel to make them rustproof. In this process zinc first forms an alloy with the underlying metal, and then additional deposits of zinc form a protective layer. In contrast with galvanizing, this coating is not pure zinc, but a zinc-iron alloy.

Sherardizing is performed in a steel drum about 18 in. in diameter and 3 or 4 feet long. Alternate layers of zinc dust and material are placed into the drum, filling it within a few inches of the top to allow for expansion. The drum is then placed in a fixture and revolved at about one rpm. while heated by a gas flame or resistance heater. The complete operation requires about 12 hours at a temperature of 730-750 deg. F. (390-400 deg. C.). At end of heating period the drum is set aside and allowed to cool without opening as the zinc dust will fuse and burn if exposed to the air while hot. After cooling, the drum is emptied and the surplus zinc dust saved.

Composition of the zinc dust is important in the process of sherardizing. It is common practice to start with a mixture of 80 per cent metallic zinc and 20 per cent zinc oxide. During the process the percentage of metallic zinc will decrease and iron will accumulate in the mixture. Best results

requires about 12 hours at a temperature of 730-750 deg. F. (390-400 deg. C.). At end of heating period the drum is set aside and allowed to cool without opening as the zinc dust will fuse and burn if exposed to the air while hot. After cooling, the drum is emptied and the surplus zinc dust saved.

Composition of the zinc dust is important in the process of sherardizing. It is common practice to start with a mixture of 80 per cent metallic zinc and 20 per cent zinc oxide. During the process the percentage of metallic zinc will decrease and iron will accumulate in the mixture. Best results are obtained when the metallic zinc content of the dust is not allowed to drop below 69 per cent and the iron is not allowed to go above 3.75 per cent.

As in galvanizing, the thickness of the zinc deposit is such that allowance must be made for the increase in dimensions. When threaded parts are to be sherardized, an allowance of 0.004 to 0.009 in. must be made for this deposit. Calorizing is carried out in much the same manner as sherardizing except that a coating of aluminum is obtained.

Whereas electroplating formerly was carried out with a view of improving the appearance of the base metal--for example, gold or silver plating for decoration--today plating is applied primarily to protect the base metal from corrosion. For bright protective finishes, steel is electroplated with nickel or chromium. The protective value of nickel, plated directly on steel depends almost entirely upon the thickness of the coating. At least 0.0005 in. is required for good protection under mild conditions, and at least 0.001 in. for severe conditions. While this thickness of nickel coating will resist rust, it has little resistance to tarnish. Chromium coating has the advantage over nickel. A chromium coating only 0.00002 to 0.00003 in. thick over nickel adds but little to the protective value of the coating but maintains its bright appearance because of the resistance of chromium to tarnishing. Thick coatings of chromium from 0.00005 to 0.0001 in. not only greatly increases its resistance to tarnish, but also improves the protection which it affords against corrosion.

Chromium and cadmium are two of the most commonly used electro-deposited coatings for iron and steel parts. Chromium plating has caused some trouble,

however, in showing signs of pitting or discoloration, but usually this is because the chromium deposit is too thin. In such cases, the procedure has been to copper plate and buff, nickel plate and buff, and then apply a flash of chromium followed by a rinse in cold water, after which water stains are wiped off with a cloth. If a heavier coating of chromium is applied, many failures in chromium plating are eliminated.

Chromium plating differs from other plating processes in that insoluble anodes are used. Chromium anodes can be used, but as they are more expensive than chromic acid added to the plating bath, and as the anodes tend to produce an excessive concentration of chromate in the bath, they are not advantageous. For the insoluble anodes, a composition of 94 per cent lead and 6 per cent antimony has been found satisfactory, and the plating solution is replenished by adding chromic acid. Temperature of the plating bath is held to about 110 deg. F. (45 deg. C.). Current density required is about 100 to 200 amperes per square foot. Cost of chromium plating is high, and depends on size and shape of pieces as well as the thickness of plate, so that no cost figure can be given.

Cadmium plating has been extensively applied in recent years. One advantageous feature about a cadmium finish is that a coating fairly resistant to corrosion can be applied to threaded parts without calling for undersize threads or oversize holes; an important factor.

Cadmium plating machines are equipped with steel anode holders with cadmium balls as anodes. The plating solution is maintained at room temperature, with current densities from 9 to 47 amperes per square foot.

Spring steel that is cadmium plated often becomes brittle due to the absorption of hydrogen during plating process. Brittleness can be remedied by heating the parts in an oil bath for two or three hours at a temperature of about 480 deg. F. (250 deg. C.).

(b) Non-Ferrous

Copper and brass parts after being cleaned can be coated with pure tin or an alloy consisting of 42 per cent tin and 58 per cent lead. This coating is applied by a hot dipping operation similar to that used in galvanizing. However, the coating is not so heavy as that of zinc. On nuts and bolts that have usual thread tolerances it is not necessary to cut undersize threads.

Tin coatings can be applied to copper and brass parts chemically by the cream of tartar process. Parts to be tinned are placed in a copper container between layers of perforated tin anodes in close contact with the parts. A boiling solution of cream of tartar, (1/2 oz. per gal. of water) is added to the container, and the container heated. The solution is kept boiling continuously for 4 to 6 hours. The tartar solution dissolves the tin which is then deposited on the copper and brass parts. Once the surfaces are coated, no more tin can be deposited, so that the parts receive a very thin coating. After removing the parts from the container, they are thoroughly washed in hot water to remove all traces of the tartar solution.

Of the two methods of coating non-ferrous parts the hot-dipped tin-lead coating has been used in preference to the tartar process, because the coating obtained by the tartar process is rapidly attacked by atmospheres such as found in oil fields where hydrogen sulphide gas is present. In wet weather, the finish may be destroyed in a few days. To resist such conditions, the lead-tin coating was developed in the laboratory, arriving at a composition of 42 per cent tin and 58 per cent lead which proved to be most resistant to corrosion. Another important advantage of tin-lead coating is that it forms an excellent base for soldering, whereas it is impossible to solder over a tartar coating.

Protection of aluminum with anodic oxide coatings of various kinds, has been practiced for many years, but until recently anodic coatings have been used mostly for the protection of aircraft parts, although it was also used for refrigerator ice cube trays. Early processes employed a 3 per cent solution of chromic acid for the electrolyte. The principal objection to its use was the fact that the coating was dark gray in color and a whiter finish was preferred.

that may become heated for short periods of time.

Thin coatings of either cadmium or zinc furnish better protection against corrosion of steel in most normal climates than do coatings of nickel or chromium of equal thickness. In marine or rural atmosphere either zinc or cadmium coatings with a minimum thickness of 0.0005 in. furnish protection against rust for several years. However, zinc in a marine atmosphere forms a basic zinc carbonate while cadmium does not form this carbonate. Consequently, cadmium surfaces preserve a better appearance around a marine atmosphere than do zinc coatings.

In electrical devices such as circuit breakers, switches and relays exposed to corrosive atmospheres, current-carrying properties of the contact surfaces may be affected by corrosion. Hydrogen sulphide is perhaps the most common and at the same time the most harmful corrosive gas. Copper is very susceptible to corrosion by hydrogen sulphide gas, relatively small concentrations forming black films of high electrical resistance on the metal, greatly reducing the current carrying ability of the contact surfaces. Silver becomes discolored when exposed to this gas, turning dark gray in appearance. On cadmium, hydrogen sulphide forms a light yellow film which is almost invisible, but which is a poor conductor. Silver is superior to cadmium or copper not only with respect to the electrical resistance of these corrosion films, but also with respect to the behavior of the contact.

CONFERENCES 26

FINISHES (NON-METALLIC)

I. PURPOSE OF FINISHES:
   - Protection
   - Decoration

II. MATERIALS: - (Composition and Use)
   - Primers
   - Fillers - Surfacers
   - Top Coats
     1. Paints
     2. Lacquer enamels
     3. Enamels (Oil type and synthetic)
   - Varnishes (oil and spirit types)
   - Japans
   - Oils
   - Stains
   - Solvents and Thinners

III. METHODS OF APPLICATION:
   - Preparation of surface (shotblasting - cleaning)
   - Brushing
   - Spraying
   - Flowing
   - Dipping
   - Drying - (Airdrying - baking)

IV. DESIGN OF A FINISH:
   - When to use primers, fillers, and surfacers
   - When to use paints, lacquers and enamels

QUESTIONS:

CONFERENCE 27

FINISHES (NON-METALLIC) (Cont'd.)

V. HOW TO SELECT A FINISH:
   - Materials requiring finishes
   - Service requirements
     1. Durability
     2. Appearance
   - Costs
   - Facilities for application
   - Sales appeal
     - Crinkle finishes
     - Opalescent finishes

VI. METHODS OF SPECIFYING FINISHES:

Use of standard sheets	S 21.3 - 21.4
	C 35.1 to 35.9 incl.
Obsolete finish numbers	C 36
Finish guide	S 506.1
Use of finish charts	10000 to 10052

VII. INSPECTION TRIP TO SECTION MP

QUESTIONS:

Devices for applying lubricants

A - OILS

1. Wick Feed
2. Bottle Oiler - Gravity Feed
3. Oil Bath - Splash or Oil-Ring Feed
4. Force Feed - Pump
5. Sight Feed - Gravity by Drop through Water
6. Circulatory System - Pump and Rest Tank.

B - GREASES

1. Applied by Hand
2. Guns - Zerk and Alemite Fittings
3. Pressure Cup
4. Large - One Shot Pressure System.

QUESTIONS:

CONFERENCE 29

Purchasing Department Specifications:

A P. D. Specification is primarily a contract between the purchaser (The Westinghouse Electric & Manufacturing Company) and the supplier from whom the material is purchased, stating the quality to be furnished and the tests to be made to determine the quality. In addition, it serves as a guide in inspection, and tells the designer and draftsman what the quality will be. It includes:

(a) The limiting values for the properties.
(b) Methods of test and number of tests to be made.
(c) Permissible variations in dimensions.
(d) The finish desired.
(e) Method of packing and marking.
(f) Inspection procedure.
(g) Procedure for rejection of inferior material.

Illustrations:

P. D. Specification 1556 - Cold Drawn Bessemer Steel Bars.

Standard grade in general used throughout the country. Purchased on the open market, from any supplier.

P. D. Specification 7534. Beryllium Copper Sheet.

Limited to two suppliers.
A consolidated specification which includes several grades, designated by dash numbers, as 7534-1.

M-4635 Nickel Silver Rivets.

Purchased by grade without specification, from approved suppliers. It is important to specify materials on drawing by P. D. Specification or material number. Do not put name of supplier on drawing, as supplier is likely to be changed, and this would require change in drawing.

Process Specifications:

Process Specifications are used to specify the exact procedure to be followed in the shop.

(a) In the manufacture of a material, such as cements.
(b) In the application of a material, such as babbitt, or solder.
(c) In the treating of a material or part, such as impregnation of coils.

It is necessary that the same procedure be followed every time this requires that written instructions in Process Specification Form be provided.

Illustrations:

Process Specification 50761-H - Impregnating with compound #1002.
Process Specification 115111-F - Annealing of steel forgings, hot and cold formed material, bolts, plates, etc.

Information on the process Specifications available is given in the Standards Book. For instance, the properties of materials after heat treatment is given under the properties of the material in question.

Process Specifications cover a very wide range.

Finish Specifications:

Finish Specifications describe the procedure to be used in applying the finish to the apparatus, including the materials to be used.

The finish number is used as the number for the finish specification.

The information as to what finish is to be applied to the various parts is given in the finish chart, prepared by the Design Department and specified on the drawing for the apparatus.

A list of the various finish numbers, with brief description of the finish and its application is given in the Standards Book.

Illustrations:

Finish #157-B. A two coat semi-gloss black enamel finish suitable for use as an out-door finish on protected or enclosed parts.

Finish Chart #10030 - For circuit breakers uses Finish #157-B for certain parts.

Standards Sheet C-35.5 lists Finish #157-B.

References:

P. D. Specification 1556 and card.
P. D. Specification 7534 and card.
M-4635 card.
Process Specification 50761-H
Process Specification 115111-F
Finish Specification 157-B
Finish Chart 10030
Standards Sheet C-35.4

QUESTIONS:

CONFERENCE 31

STANDARDS

(1) History and Progress of Standards

(a) Origin
(b) Progress

(2) How Standards are Established

(a) American Standards Association and other Societies
(b) Westinghouse Committees

(3) Types of Standards

(a) Design and Shop Practice
(b) Material and Parts Standards
(c) Insulation Data Standards
(d) Carbon Brush Standards

(4) Benefits Derived from the Use of Standards

(a) Uniformity in Design and Practice
(b) Lower costs due to higher activities for fewer sizes.
(c) Lower inventories
(d) Interchangeability of parts

(5) Use Westinghouse Standards

(a) Shorter deliveries for completed apparatus
(b) Lower cost apparatus
(c) Increased sales

QUESTIONS:

CONFERENCE #32

Previous conferences with Materials & Process engineers has developed that:

FOR MATERIALS:

1. Materials are authorized only after careful tests, application requirements are met, price situation investigated, etc.

2. Materials authorized only after it has been determined that
   - (a) Supply will be adequate in quantity and quality.
   - (b) Material will be uniform.
   - (c) Enough suppliers for healthy price competition.
   - (d) Will conform to customer, trade, or national requirements.

FOR PROCESSES:

1. All possible methods have been investigated.

2. Competitive tests have shown best process.

3. Adequate equipment used to insure desired results.

4. Processes will meet customer, trade, or national standards.

FOR DESIGN:

1. All previous experience has been sifted to insure best and most economical procedure.

2. Tests have been made to determine adequacy under all operating conditions.

3. Product will meet customer, trade, or national standards.

Value of standardization: - When above conditions are met, we have a material, process, or design standard which is advertised. Adherence to these standards will insure:

FOR MATERIALS:

1. Least expensive material to do the work.
2. Continued uniformity of material.
3. Adequate inspection.
4. Several sources of supply (Floods may shut down one supplier).
5. Least amount of money tied up in inventory.
6. Economical sequence of sizes.
7. Agreement with trades or national standards.

FOR PROCESSES:

1. There has been enough development to insure minimum cost.
2. Adequate machinery has been installed for processing.
3. Jobs will be done in the future the same as today, even with a totally different personnel.

FOR DESIGN:

1. Best design continues to be used.
2. That old ideas which have been discontinued are not revived.

<u>To be a good draftsman:</u>

(1) Consult Materials Standards Book, & Design Standards Book.

(2) Use only standard stock materials or design standards.

(3) Never use material or size not shown in Standards Book

<u>If you do not do this, sooner or later you will:</u>

(1) Use wrong material.

(2) Use too expensive materials, and apparatus will not be sold.

(3) Use a material whose manufacture has been discontinued, thereby necessitating a redesign with increased costs.

If you do not do this, sooner or later you will: (Cont'd)

(4) If design is changed or discontinued, you will have material in the shop which must be scrapped and charged against you.

(5) Shop will not meet shipment date due to difficulty in getting non-standard material.

QUESTIONS:

CONFERENCE 35

MANUFACTURING FACILITIES

Machine Tools and kind of work most economically performed with each:

Hand Tools

Drills

Punches

Lathes

Milling Machines

Grinders

Planers and Shapers

Turret Lathes

Screw Machines

Boring Mills

Special Machines - Coil winders and formers

Saws

Presses (Punch, forging, etc.)

Welding Outfits (Acetylene, A.C. and D.C. Arc)

Oxygraph (Acetylene Cutting)

Shears

Questions

CONFERENCE 36

MANUFACTURING FACILITIES CONT'D.

Methods of handling available:

Cranes and conveyors affect design

Machinery available:

Milling, planing, facing in lathe or boring mill would affect shape of pad or flat surface

Special process equipment required:
Designs should avoid this if possible, unless large quantity justifies

Skill of operators available:
Welded designs not successful until we train welders

Nature of work and variables as affecting amount of control and inspection facilities

Materials and designs which contain the least variables or uncontrollable items desirable

Questions

CONFERENCE 37

TOOLS, JIGS, DIES AND FIXTURES

Reasons for use of jigs, dies and fixtures:

Types of Dies:

(a) Blanking

(b) Bending

(c) Drawing

(d) Forming

(e) Piercing

(f) Forging

(g) Casting

(h) Moulding

Features which assist in simplifying tools for each of these types.

Questions

CONFERENCE 38

DRILL JIGS AND TEMPLETS

General Description

The name jig is generally applied to a special tool for properly holding some piece of apparatus requiring one or more holes to be drilled in fixed relation to each other, and for economically providing interchangeability of parts for a given assembled machine or apparatus. The type of jig used depends upon the accuracy and production requirements.

Drilling Templets

A drilling templet is generally a piece of steel plate with holes to guide the drills. It is clamped to the piece with "C" clamps. If accuracy and quantity are required, hardened bushings are provided for the drills, and over-hanging stop and screw straps for holding drilling templet to the work. These jigs are used mostly on common single or multiple spindle drilling machines.

Box Jigs

Box jigs are either of open or closed type. The open type is placed on a machine table open side up and the part placed in it and held to the base with stud and clamp, etc. Often used for flanges, motor brackets, etc.

Closed box jigs are most commonly used on our work. Drilling can be done from as many sides as the product requires. Rough castings are located on and against hardened buttons pressed against the jig walls. Parts having machined surfaces are mostly clamped against similar surfaces provided in the jig itself. Some designs require all drilling to be in relation to the center of the work, therefore special equalizing clamping facilities are provided.

Care must be taken in designing the clamping arrangements of any jig to assure against the springing of both the product and the jig. Springing of either invariably produces inaccurate work. Jigs must be able to withstand pressure of cutting tools which cause springing when the design is too light.

Box type jigs are generally used on single spindle, multiple spindle and radial drilling machines. When used on single spindle and radial drilling machines the cutting tools must be placed in and removed from the spindle at least as many times as there are sizes of tools, and on two, four, and six spindle machines, each spindle has a different cutting tool and the jig is moved from spindle to spindle. This type machine, however, does not lend itself to jigs much heavier than sixty pounds.

Cradle and Trunion Jigs

These jigs are used for heavy work having holes from different sides and covers the operations of drilling, reaming, counterboring, facing, boring, and tapping. Operations other than drilling are generally done by removing slit bushings or opening swing lids. Clamping is generally independent of the lids to facilitate accessability of the other cutting tools and to prevent springing of the lid holding the bushing. These jigs are used mostly on large radial drilling machines. Many of this type of jig are used on large circuit breaker castings.

Drilling Fixtures

Drilling fixtures are jigs which are affixed to and act as part of the drilling machine. They are used for high production and fitted to special multiple head drilling machines. C. S. Motor frames are drilled on this type machine, drilling the bracket holes on both sides and the feet holes all at the same time.

There is no limit to the possibilities of these special machines for reducing production cost of a part to be manufactured as this depends largely on the stability of production and on competition.

The locating point or points from which to work on a part, is determined by its relation to some other part in the final assembly. Generally a milled slot, a face, or combination of faces is used, as other parts having mating faces must assemble readily. More accurate work is obtained by drilling from a milled or machined surface than by milling from drilled holes. Parts drilled from milled surfaces are as accurate as the jig itself, but parts milled from drilled holes are no more accurate than the fixture setting, variation in clamping, lost motion in the machine and variation in the drilled locating holes.

A very small percent of our work is milled from the drilled holes and invariably when it is done, it is due to the shape of the piece being such that it is impossible to hold it properly without springing. Whether a part is to be drilled complete in one jig or in a number of jigs depends largely on its shape, size of holes, and shop equipment activity. As a general rule, a part having various size holes on numerous sides would be best handled in a single jig, thereby insuring fixed relation between all holes. On large relatively simple castings having a number of same size holes on one side and a number of same size holes on another side, such as our railway motor frames, it is best to use a number of simple jigs, drilling each side on a multiple spindle machine, thereby getting all the holes drilled on a side for the cost of one.

The cost of jigs is kept to a minimum by the use of standard stocked jig parts, lid screws, drill bushings, clamping cams, thumbs, jack screws, etc., which are carried for this purpose.

The effect of variation in size of holes and number of faces drilled on the cost of tools and product, is in direct proportion to the number of holes and sides, according to the type of machine on which the work is produced and the size of the jig. For instance, a small casting having four sides and a total of six different size holes would be best produced on a six spindle multiple spindle machine having all drills set at the proper speeds. A single spindle machine equipped with a quick change chuck and a set of six drills to fit same would be second, while a standard single spindle machine equipped with a standard chuck would be the most costly. On heavy jigs, however, it is best to change the various cutting tools for each side, as too much time and labor are required to turn over the jig.

Questions:

CONFERENCE 40

FIXTURES

Planing

Planing is one of the oldest methods of machining surfaces of machine parts. Used mostly for castings where mass production was not the rule. Castings were set up to lines laid out on the castings from drawings so that all surfaces would be as close to the drawing as possible. Skill was required in clamping work to prevent springing when removing necessary amount of metal and to maintain good surfaces with least amount of clamping. Today a number of castings are machined at one setting with quite simple fixtures, which obviate necessity of laying out the work. Castings are located to best advantage for machining, and tools are generally set to a templet or to fixed pins or stops in fixtures. Modern planing machines often have two tool posts on overhead crossrail or side head on each of the side uprights, and it is not uncommon to have four tools in operation at same time. Various feeds and speeds are provided to cover the various metals machined. Planes as a rule are used either for low production or for large work and high production, where cost of special milling cutters would be prohibitive. Our railway and mill motor frames are of the latter class and large power apparatus of former class.

Milling

Milling is another method of removing metal to produce finished surfaces to drawing dimension and is best method of producing duplicate parts in mass production. Special fixtures and cutters or sets of cutters are required. There are a number of different types of milling machines, the most common being the plane and universal horizontal types. These machines sometimes have single facing cutters fastened to the front of the spindle for facing the surface of one end of a casting, or a cutter, or a series of cutters on an arbor which is driven by the spindle at one end, the other end supported by an overhanging arm. The product passes under this arbor and the cutter produces the contour or shape required on the drawing. The relation of the cutters to the fixtures is generally procured with gauges or set pieces on the fixtures.

The vertical miller is similar to the horizontal type except the head of the machine overhangs the table and milling cutters are vertical in position (similar to a drill in a drilling machine) and the work on the table passes under it to remove the metal for finishing. This type machine is often called a Profiler and is chosen mainly for its convenience in handling a type of work that would be awkward and impractical to mill on the horizontal machine as the height from the cutters above the table would cause too much chatter and unnecessary tool upkeep. Surfaces on large flat work are best milled on this type machine.

Still another type horizontal type milling machine, sometimes known as a slab miller is used for heavy milling of large surfaces. This type machine is similar to the planer, except an arbor with cutter is set across the housing upright and the table and work pass under this arbor and between the housings.

Bosses or smaller faces on large castings are often milled on vertical millers. In this case the work is fastened to floor plates and the machine with the facing cutter is moved on its bed while the operation is performed. Very few fixtures are used on this type work and the faces are milled in relation to some previously finished surface or center lines.

Boring

Boring is done on quite a number of machines. There are the Standard Vertical Boring machine and the horizontal or Jig Boring machine. The type of machine to use is determined by the class of work to be machined. In general, large diameter deep work or heavy work is best done on horizontal machines; lighter and shallower work on the lathe. Large upright work with long holes or several holes in line is best done on the horizontal machines. Boring a number of holes accurately in relation to each other, like the bushing holes in drill jigs, is best done on the jig boring machines. Very often accurate work is produced by use of a special boring bar run in bushings of a jig on the standard radial drilling machines. The two most common types of vertical boring machines consist of one having a cross rail over the table with one or more tool posts or rams, and a side head for turning on one side, while the other has a turret head on the cross rail and a head at one side for turning. For plain, simple and large work, the former is used and for work having numerous shapes of cavities, grooves, etc., on the inside, the latter is used. Both these types have all the feed and speed mechanisms required for modern production. Work of size and shape impractical to swing on a vertical machine is done on the horizontal type machine either with special bars with tools in them, or special heads with tools on the spindle nose.

Turning

Turning is one of the oldest manufacturing operations known, and the operation is performed mostly on the lathe. It is used for both wood and metal; however, we will cover the metals only. There are quite a number of types of lathes, and each has its particular application in modern industry. The most common lathe is used for rough turning shafts, the work being finished to size on special heavy grinding machines. These machines consist mainly of head stock with drive chuck with heavy clamp type tool rest on the carriage and the tail stock. Cobalt and Tungsten high speed tools are generally used for this work.

The Engine lathe is the most universally used machine, and it is provided with universal chuck, face plates, taper turning attachment, speed screw, and necessary set of gears for cutting all standard and popular thread, etc. In the tool rooms it is indispensable, skilled help is required to operate this machine. Accuracy, rather than quantity, is the rule with work produced on this machine.

The turret lathe is strictly a production machine and there are quite a variety of machines of this type, each make having some particular application for a certain type of work. Each face of the turret, and often the cross plate, must be fitted with special base slides and tools performing a fixed operation on the work. The tools of one face may have a centering drill, the next a through drill, the next a boring tool, then a reamer, and last a tap--according to the number of faces and operations required. As some shops are equipped with two-way turret machines, some with four-, five-, or six-sided turrets, it requires quite some engineering of tool set up to suit the product. To purchase a turret machine for a known product is quite simple, but to tool up four-sided machine for a six-sided operation is quite a problem, and extra combined-operation tools must be designed to suit. These machines are more or less automatic in operation. The hand screw machines are next in line and are somewhat the same in principle as the larger turret lathes used for mass production on smaller work; next are the fully automatic screw machines which are used for a variety of work and quite a number can be operated by one man.

Questions

FIXTURES (cont.)

Cutting Tools

Cutting tools used on lathes are of all shapes and sizes and include tools made of carbon, high speed, super high speed and carbide steels. The steel in the tools is based entirely on the quantity, accuracy and type of machine on which the tools are used, and the hardness of the material to be cut. The condition of the machine must be suited to the hardness of the tool used. Tools of carbon steel will cut surfaces travelling at 50 ft. per minute; high speed steel, 80 ft. per minute, cobalt high speed, 110 ft. per minute; and carbide tool, 240 ft. and up per minute. The price of these cutting tools varys from 25 cents to $250 per pound. These speeds are for soft steels, and are higher for non-ferrous material, also the surface feet vary with the amount of feed used; the greater the feed or chip thickness, the less the surface speed.

Locating points

Points from which to locate work in jigs or fixtures should be hard to resist change by wear and should be so placed as to prevent dirt or chips accumulating. One method is to place a hole immediately under a side stop and at the sides of a bottom stop. Holes are cut in sides of fixtures to prevent chips gathering or in order to remove them easily.

Clamping should be applied as directly over the stops as possible especially where the product is likely to spring.

Work may be spoiled because of springing of fixture or jig when clamping. It can easily be seen that where several holes are drilled in a heavy non-springing product with a light jig which springs when tightened or with improperly arranged screw or clamp, holes will be thrown out of alignment thereby spoiling the work. It is good practice to avoid placing clamping screw in lids or covers of drill jigs for above reasons, but to provide separate clamps if possible.

The most commonly used clamping arrangement is the clamp or screw for drill jig work of the throw-over or box type, but cams can be used for quite a number of fixed-on-one-position drill jigs or fixtures. The main objection to clamping work with cams is the variation of the size of the part where the clamping is applied. High production work is often benefitingly clamped by air, oil, or magnets (pneumatic, hydraulic, or electric), especially where the product is placed by some handy devise where the ordinary clamping would be unhandy, unaccessable and dangerous to get at. The time required to set up these methods of clamping on normal or low activity makes their use prohibitive.

Bending

The art of bending material covers a large range and the tools used for same should be designed by men having a background of experience, knowing how the materials will act, whether it will bend in one operation or break. The amount of spring back should be known, and whether the work should be first heated and to what temperature, should also be known. As the result of these qualities is to a great extent unknown, it often requires quite a bit of experimental work on tentatively designed tools to make them work satisfactorily.

Assembly

Assembly covers the putting together of previously machined or finished parts, and the more accurate these various parts are, the more easily and quickly will the assembly be performed. Fixtures are sometimes made for lining up various parts while fastening them together. Sometimes parts are added to a machine or structure by different men while it moves along a conveyor or again there is the welding assembly fixture where various parts are held in proper relation to each other while the welding is done.

When a piece of apparatus is machined, and assembled, it is finally tested by some suitable method to insure that it will give entire satisfaction to our customers.

Questions

CONFERENCE 41

MANUFACTURING OPERATIONS CONT'D. (2)

Alternate methods - milling versus planing

grinding versus turning

punching versus drilling

Advantages and disadvantages of each.

Questions

CONFERENCE 42

MANUFACTURING OPERATIONS CONT'D. (3)

Consider the advantages and disadvantages: The field of application and relative costs of the following:

(a) Acetylene cutting

(b) Acetylene welding

(c) Seam welding

(d) Resistance welding

Questions

CONFERENCE 43

MANUFACTURING OPERATIONS CONT'D. (4)

Consider the field of application of each of the following and the relative costs:

(a) Automatic welding

(b) Spot welding

(c) Seam welding

(d) Resistance welding

Questions

CONFERENCE 44

MANUFACTURING OPERATIONS CONT'D. (5)

Welded structures:

- Welding as applied to jigs and fixtures
- Types of fixtures required for production
- Position welding
- Considerations affecting decision as to whether to use welded parts or castings

Questions

JR. DRAFTING CONFERENCES

Table of Contents

48. Manufacturing Processes, Foundry Procedure, Casting, Pattern Molding and Coremaking
49. " " Foundry Procedure, Melting Methods, Cleaning, Finishing & Inspection
50. " " Permanent Molding - General
51. " " " " Cont'd. Scope & Limitations. Hot Pressing Method
52. " " Metal Stamping Details
53. Lamination Manufacture
54. Heavy Drawing and Blanking Operations
55. Manufacturing Cost Analysis
56. " Processes, Coordinating Engineering Design and Factory Equipment
57. " Processes cont'd., Principles of Interchangeable Manufacture
58. Inspection, Purpose & Methods
59. " Organization
60. " Tools and Equipment
61. Testing - Industrial Motor Apparatus
62. " Generator "
63. " Switchgear "
64. " Transportation "
65. Patent Drafting
66. Manufacturing Costs
67. Engineering & Development Accounting
68. Service Department
69. Micarta
70. Plastics
71. Industrial Relations
72. Safety & Accident Prevention
73. Waste Elimination
74. Conservation of Materials & Time
75. The Central Engineering Laboratories
76. Design for Appearance
77. Sales
78. Maintenance and Renewal Parts
79. Generating Apparatus - D. C. Machines
80. " " A. C. "
81. Switchgear Apparatus - Switchboard Apparatus
82. " " Circuit Breakers
83. " " Protective Devices
84. Transformers
85. Meters and Meter Connections
86. Control Apparatus. Elementary Control Circuit
87. " " Construction & Function
88. Industrial Motor Apparatus, D. C. Motors
89. " " " Induction "
90. " " " Welding & Welding Equipment
91. Transportation Equipment. Motors & Generators
92. " " Control
93. Gearing
94. Closing Address

CONFERENCE 1

FOLLOWING THROUGH AN ORDER

Customer:

The customer submits his requirements to the Sales Department through the salesman.

Sales Department:

The Sales Department preferably sells standard apparatus carried in stock; secondly, apparatus which has been previously manufactured where designs, tools, etc. are already available. Special apparatus is furnished where necessary or where standard apparatus does not meet customer requirements.

Engineering Department:

The engineers decide what to supply to meet customer requirements.

Manufacturing Department:

The Manufacturing Department builds the apparatus according to specifications and drawings furnished by the Engineering Department.

Scheduling the Work:

The necessity for carefully scheduling the work in all departments is apparent when one considers the great number of orders and the vast variety of separate parts manufactured. Careful scheduling permits completion of parts and finished apparatus on the scheduled dates, and without interference with other orders going through the works at the same time.

Observation Trip to the Works - Manufacture of Motors

Observe methods of mass production, particularly of medium size machines. Winding and connecting of rotors of A.C. machines and armatures of D.C. machines, die casting of rotors, balancing of rotors, etc.

Observe the large stocks of finished machines and parts which facilitate rapid filling of customers' orders. Note also semi-finished part stocks.

Engineering Department

Function:

Engineers make the designs and prepare sketches and other information necessary for the drafting room to produce the drawings required. They supply information to the Clerical Engineering Department, which in turn transmits the manufacturing information to the shop.

Draftsmen by means of the drawing, instruct the shop what to make.

Clerks prepare the necessary detail instructions required by the shop in the various stages of the manufacturing process.

Questions:

CONFERENCE 11

PRODUCTION OF A DRAWING

Preparation of a Drawing:

1. The sketch of the idea (or panel layout).
2. A schematic layout.
3. Decision as to parts or connections.
4. Checking of clearances. (Examples).
5. Detail drawings:
    (a) Pencil drawings.
    (b) Pencil tracings.
    (c) Ink tracings.
6. Reproduction of tracings: as many copies may be obtained as are required.
7. Often customers require special drawings (Example of Navy job.)
8. Finally there are the assembly drawings (Examples of prints, tracings, drawings and sketches. Discuss features).

Trip to the Works - Manufacture of Switchboards and Circuit Breakers

Note high voltage apparatus, particularly large entrance bushings. Observe clearances and their effect on the size of apparatus. Note use of wiring diagrams.

General Suggestions

Older men in drafting rooms can materially help beginners who show a willingness to profit from their experience and advice.

Advancement will probably not be clearly marked, but better work will assigned as fitness is demonstrated. As conditions require, junior draftsmen or detailers may, from time to time, return to less desirable work.

Emphasis on the need for technical education as essential to progress.

Need of physical activity, especially outdoor exercise, Westinghouse Club or similar activities.

Necessity of getting work out on time. All work is scheduled and dates must be met.

Drafting experience is useful for many lines of advancement, especially in engineering work. Many executives at some time in their careers, worked on the drafting board.

Questions:

CONFERENCE 3
ORGANIZATION OF THE DRAWING ROOM

Most of our drafting work pertains to mechanical and electrical lines. Other drawing activities include patent, structural, architectural, piping, tool design, etc.

Supervisor -
The supervisor may be a mechanical engineer or a supervisor of drafting practice.

Layout Men or Designers -
Men with technical training and considerable experience in shop methods. It is their function to direct the individual drafting jobs involving new designs.

Draftsmen -
Experienced men who make assembly drawings and are able to do some layout work. They should be familiar with shop methods and systems.

Detailers -
Make drawings of apparatus or elements. They should have some knowledge of the shop and know the systems.

Junior Draftsmen -
Beginners who expect to advance to more responsible work. They make tracings, changes in tracings, simple drawings, or do other work as directed.

OBSERVATION TRIP TO THE WORKS - MANUFACTURE OF CONTROL EQUIPMENT

Observe manufacture and assembly of small parts such as contactors, etc. Note the use of angle iron and tubular frames for control units.
Note forming of cabinets, covers, etc.
Observe the functioning of conveyor systems and other important labor saving devices.
Note the use of wiring diagrams in connection with the assembling, wiring and testing of apparatus

NECESSITY OF TECHNICAL TRAINING FOR ADVANCEMENT

In drafting work, a thorough technical education is necessary for advancement. Men with technical knowledge and experience are always in demand and the opportunity for advancement to higher grades of work with consequent higher rate of pay naturally follows.

Opportunities for training in the Pittsburgh District -
Night Courses are conducted by Carnegie Institute of Technology, University of Pittsburgh, Duquesne University and Westinghouse Technical Night School. Information regarding educational opportunities may be obtained from the Industrial Relations Department.

QUESTIONS:

CONFERENCE 4
THE ENGINEERING SYSTEM

Rigid adherence to the system--

1. Assures consistency in design
2. Prevents errors of interpretation
3. Assures use of available raw materials and finished parts.

(Illustrate by striking examples)

The importance of the above can be realized when we consider that the average drawing is consulted by at least 18 groups, possibly 40 men: Engineering - Drafting - Manufacturing Information - Routing - Production - Rate - Inspection - Mechanical - Cost - Customer - Sales - Cost Analysis - Tool Design - Renewal Parts - Catalog - Patent - Purchasing - Service.

Trips to Works - Manufacture of Generating and Transportation Equipment

Observe the large machines being built
Note particularly the large and heavy sections of apparatus; both castings and welded; large machine tools, cranes and the extensive floor space required.
Observe acetylene cutting of steel of heavy cross section
Note the shaping of large and heavy sections

Standard Book - Contains all System Information

The standard book is the draftsman's bible. It contains complete system information which must be followed.
It lists materials and standard parts, giving costs.
It shows details of preferred design.
It must be consulted continually in order that all parts conform to the system throughout.

Prime Function of the Drafting Room

Is to produce instructions (drawings) on time.

Drawings must conform to the system to good practice as established by the Company.

Drawings must be made so that they can be interpreted in only one way.

This insures that the product has the desired quality; that it is correct in design - does what is required; is most economical in design; uses wherever possible, parts already available and manufacturing equipment already installed.

Questions:

CONFERENCE 5

FUNCTION OF THE ENGINEERING ORGANIZATION

The function of the Engineering Department is to interpret customer requirements and provide adequate equipment at the lowest cost consistent with the Company's standard of quality.

ORGANIZATION:

Vice President -
Has charge of the central engineering activities and coordinates the engineering activities of the several divisions of the Company.

Engineering Design Departments -
Are responsible for all engineering design pertaining to apparatus of the department; they are grouped into Design Divisions and Design Sections.

Research Laboratories -
Carry on development programs in any line in which the Company may have an interest.

Engineering Laboratories & Standards -
Provides information on materials; operates laboratories for the development and testing of apparatus.

Feeder Engineering -
Develops and establishes materials and processes.

Engineering Service Department -
Interprets, formulates, and transmits engineering information to the shop.

Design Sections (According to apparatus) -
- Division Engineer - In charge of an Engineering Division
- Section Engineer - In charge of an Engineering Section
- Design Engineer - Responsible for mechanical or electrical design.
- Shop Engineer - Contact man with manufacturing sections
- Drafting Group -
  - Layout men
  - Draftsmen
  - Detailers
  - Junior Draftsmen
- Clerks - Transmit engineering information and carry on the routine clerical work of the department.

DESIGN:

Apparatus falls into two general groups:

Small Quantity - Usually special apparatus built to meet customer's specific requirements.

Large Quantity - Standard apparatus used in large quantities and regularly manufactured.

General Information Concerning Small Quantity Production:

The requirements depend upon customer specifications.

The Engineering Department designs the apparatus so that it can be built with a minimum of engineering and manufacturing cost.

In order to keep down costs, maximum use is made of any existing parts and tools.

When economical, a minimum number of castings is used. New materials, tools, etc., are also kept at a minimum.

Appearance is also important, but may be reasonably sacrificed to some extent for economy.

Since engineering information for this class of work will have only limited use, it is not desirable to go to great expense in its preparation.

General Information Concerning Large Quantity Production:

The requirements depend upon customer demand, trade preference, economical manufacture, performance adequate to meet various conditions, etc.

The Engineering Department makes analysis of existing competitive apparatus.

When new apparatus is designed, the engineers determine the sizes, ratings, etc., according to the preferred number system.

This class of apparatus must have wide sales appeal and satisfactory performance under all possible conditions.

The patent situation is carefully studied to prevent infringement of other manufacturers' rights and so that our own business will be properly protected.

Attention must be given to future renewal parts business, as this apparatus will be current over a period of years.

A great deal of preliminary design, making of models, testing, etc. is necessary when bringing out a new line of apparatus. Frequent consultations with manufacturing, inspection, sales, service and other departments are necessary.

A final cost analysis is made to assure prices that are competitive.

When the final design is decided upon, tool models are constructed and final tests made. This type of apparatus involves production in large quantities, over a period of years, consequently the engineering information must be of a more permanent nature and is therefore more expensive.

Questions:

CONFERENCE 6
REPRODUCTION PROCESSES

Pencil drawings can be made in less time and at less expense than ink drawings and are satisfactory for special apparatus where the probable activity is low. In general, drawings for standard lines of apparatus, or special designs where repeat orders are anticipated, should be made with ink. Either type, if properly made, can be reproduced.

BLUE PRINTS (NEGATIVE)

The method of making blue prints is fairly well known. Like in photography, the result of the first exposure is always negative. Blue prints were therefore not negative by choice, but because they represented the quickest and cheapest way of reproduction available.

Blue print paper can be procured in a variety of sizes and of various qualities. If an exceptionally good blue background is required, a one hundred per cent rag stock paper containing twenty-five to thirty-five per cent rag may be used.

The treated paper can be exposed and developed in a continuous blue print machine at the rate of twelve feet a minute, providing the original subject is good. Otherwise, the printing and developing speeds will vary from two to twelve feet a minute.

The paper we use comes in rolls two hundred yards long by thirty-nine inches wide. It contains approximately thirty-five per cent rags and sixty-five per cent sulphite.

	General Use	Cost - D Size	Time Required
Blue Prints	Easy to make	$.02	3 minutes

See Exhibit #1

BLACK LINE PRINTS (POSITIVE)

The black line process permits the making of a black and white positive print directly from the original without the use of a negative. It requires no special equipment other than the printing unit of the usual blue printing machine and a compact BW developing machine.

Procedure:

The black line paper is exposed in the blue print machine with the original transparent or translucent subject exactly as in making a blue print. The exposed paper is then introduced into the developing machine. Black line prints can be developed as rapidly as the operator can feed them into the machine, the process being somewhat faster than with blue print paper. Paper can be purchased in rolls of suitable width or sheets cut to tracing size to eliminate waste or trimming. Developing chemicals are supplied in powder form, from which developing solution of the proper strength can be mixed.

The advantage of black line prints over blue prints is that any subject matter that has been typed, written or drawn on transparent or translucent paper or cloth may be reproduced by this process more quickly than can blue prints.

	General Use	Cost - D Size	Time Required
Black Line Prints	Match up with typed or printed sheets	$.025	2 minutes

See Exhibit #2

BROWN PRINTS (NEGATIVE OR POSITIVE)

Brown print negatives or positives are made in the same manner as blue or black line prints. Negatives have clear sharp white lines, contrasting against a dark brown opaque background. Positives have clear brown lines contrasting against a white background. Blue and brown print cloth is occasionally used for work of a special nature.

	General Use	Cost - D Size	Time Required
Brown Prints	Reproductions with modifications, cuts, blue line prints.	$.04	6 minutes

See Exhibit #3

PHOTOSTATS (NEGATIVE AND POSITIVE)

Photostat paper is highly sensitized, making it necessary to photograph the subject through a lens in the same manner as photographs are made, by the use of a special photostat machine. No intermediate negative is required, copies being produced in correct position.

As the photostat paper copies are made, they are cut from a roll of paper, developed and fixed in the machine itself, no dark room being required. When washed and dried, the copies are all ready for use. Printed or written documents, blue prints, records, maps, fabrics, small tools, machine parts, etc., may be copied in a few minutes. The high orthocromatic property of photostat paper permits copying of subjects which may be in color or combination of colors. Red, blue or purple typewriting, blue prints, sealed or stamped markings in color, are all readily photographed, appearing in their relative shades of gray and black. When properly developed, fixed and washed, photostats will not fade.

	General Use	Cost - D Size	Time Required
Photostats	Reproductions from originals too dense for blue or black and white prints.	$.09	30 minutes

See Exhibit #4

TRACING REPRODUCTIONS (POSITIVES - PHOTOLITHO)

Tracings reproduced by this process are expected to be permanent records, warranting the use of the best materials. Imperial or Rival tracing cloth, recognized as the best grades on the market are used. It is waterproofed on both sides and sensitized on the dull side as received from the manufacturer. It is sensitive under natural light but may be safely handled under artificial light.

Subjects to be reproduced must have lines of sufficient density to permit making a good van dyke or brown print because the brown print is used as the negative in printing on the reproduction cloth. To insure perfect contact, brown prints that are to be used for reproduction purposed are made in a vacuum frame. The printing on the cloth, using the brown print as a negative, is made in the same way.

When printing from negative to cloth has been completed, the cloth is developed similar to the photographic negative.

At one stage of the process, any part of the reproduction may be wiped out. It is thus possible to make a reproduction from an existing tracing and eliminate any desired views or dimensions and other views or dimensions added. A marked blue print illustrating changes wanted should be attached to the original. Reproductions can be made direct from pencil drawings on paper or cloth, and from existing tracings without the aid of a tracer.

Only the best drawing pencils should be used in making drawings for this process, preferably grade H or 2H for all construction lines and grade HB for all lettering. Exceptional care must be exercised in making drawings on paper, as ordinary pencil work will not produce satisfactory results. All lines and lettering must be sharp, opaque, and of the same density. Tracings that are becoming worn or those that have been torn can be reproduced. However, it is impossible to reproduce a very dirty or badly worn tracing.

Changes can be made on reproductions in the same way as changes are made on regular tracing cloth, i.e., views or dimensions can be erased and new dimensions or views can be inked in.

	General Use	Cost - D Size	Time Required
Tracing Reproductions	Extra copy of tracing may be required or tracing cloth original may be required when original is in pencil	$.41	60 minutes

See Exhibit #5

FILING AND REQUISITIONS

Tracings are filed in the Tracing Vault, the primary index being the size of the tracing, i.e., A, B, C, D, and J. The secondary index is numerical.

Requisition Form 11977, is used in requesting reproductions and the printed instructions on this form make it self-explanatory. Form numbers have been assigned to the several sizes of tracing cloth, pencil cloth, etc. and in several cases, special forms have been provided for individual departments or plants.

See Exhibit #6.

Questions:

Dates
12/21/34
12/21/34
12/24/34

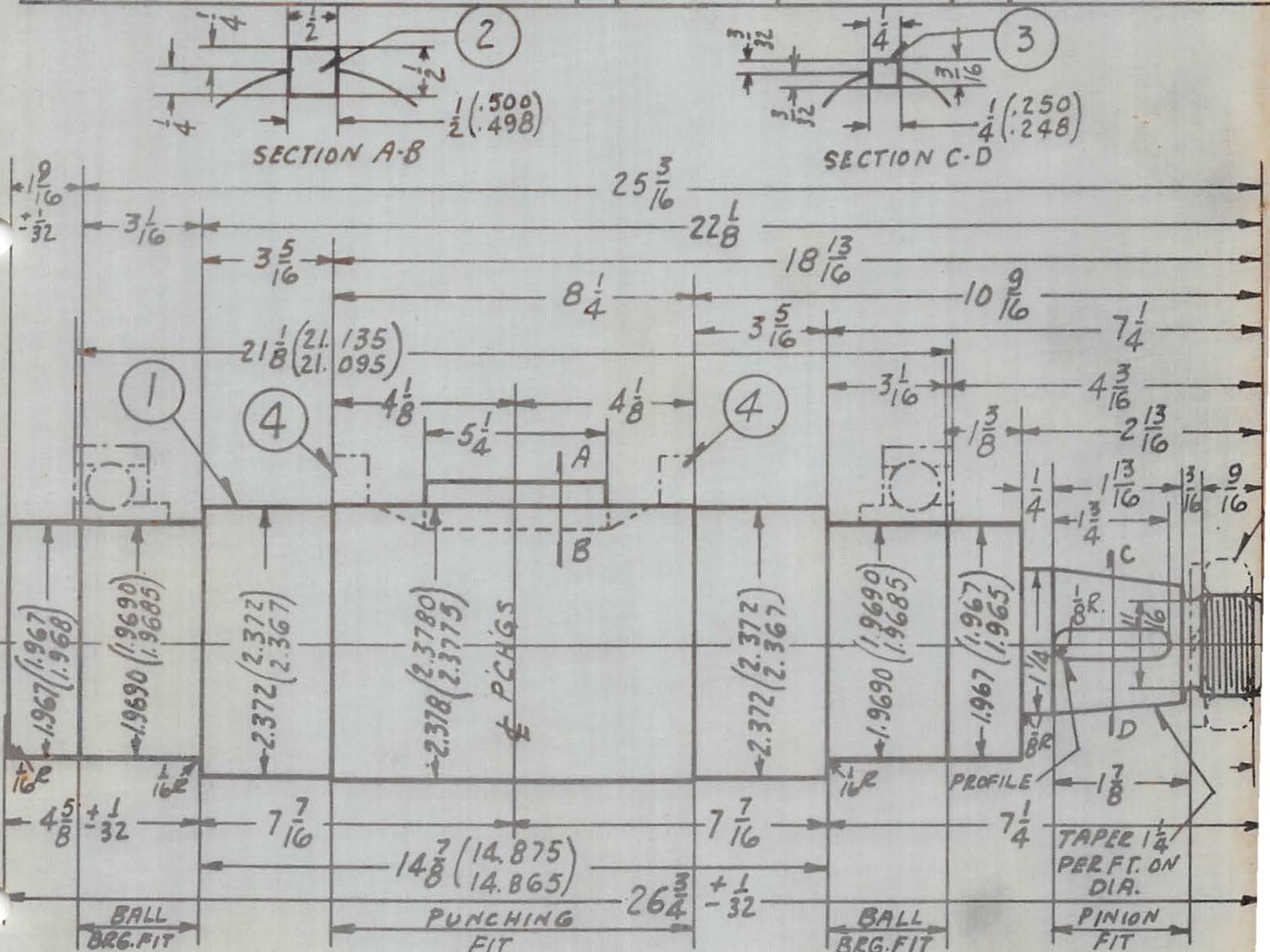
WESTINGHOUSE ELECTRIC & MFG. CO., EAST PITTSBURGH, PA., U. S. A.

MOTOR A.C. FRAME #365 TYPE "CS" SPECIAL

DIMENSIONS IN INCHES — SHAFT — SCALE N.T.S

DWG. 49-D-320 SUB. 1 — BILL OF MATERIAL — FINISH CHART 10028

Item	Description-Material-Ref. Dwg.	Fin. Chart Line No.	Style No.	Pat No.	Req.	Tool Record Space. No. in ◯ = Item No.
1	SHAFT FROM 26¾ OF 2½ DIA. S.BAR #1422					
	EST. ROUGH WT. = 37.18# FIN. WT = 25.75#				1	
2	KEY		266470		1	
3	KEY FROM 1¾ OF 3/16 × ¼ C.R.S. #2084				1	
4	RING		822625		2	
5	7/8 LOCK WASHER				1	
6	7/8 LOCK NUT				1	



FINISH ALL OVER - NO SHARP FILLETS ALLOWED.

Tool Reference Dwg. No. 49-D-32

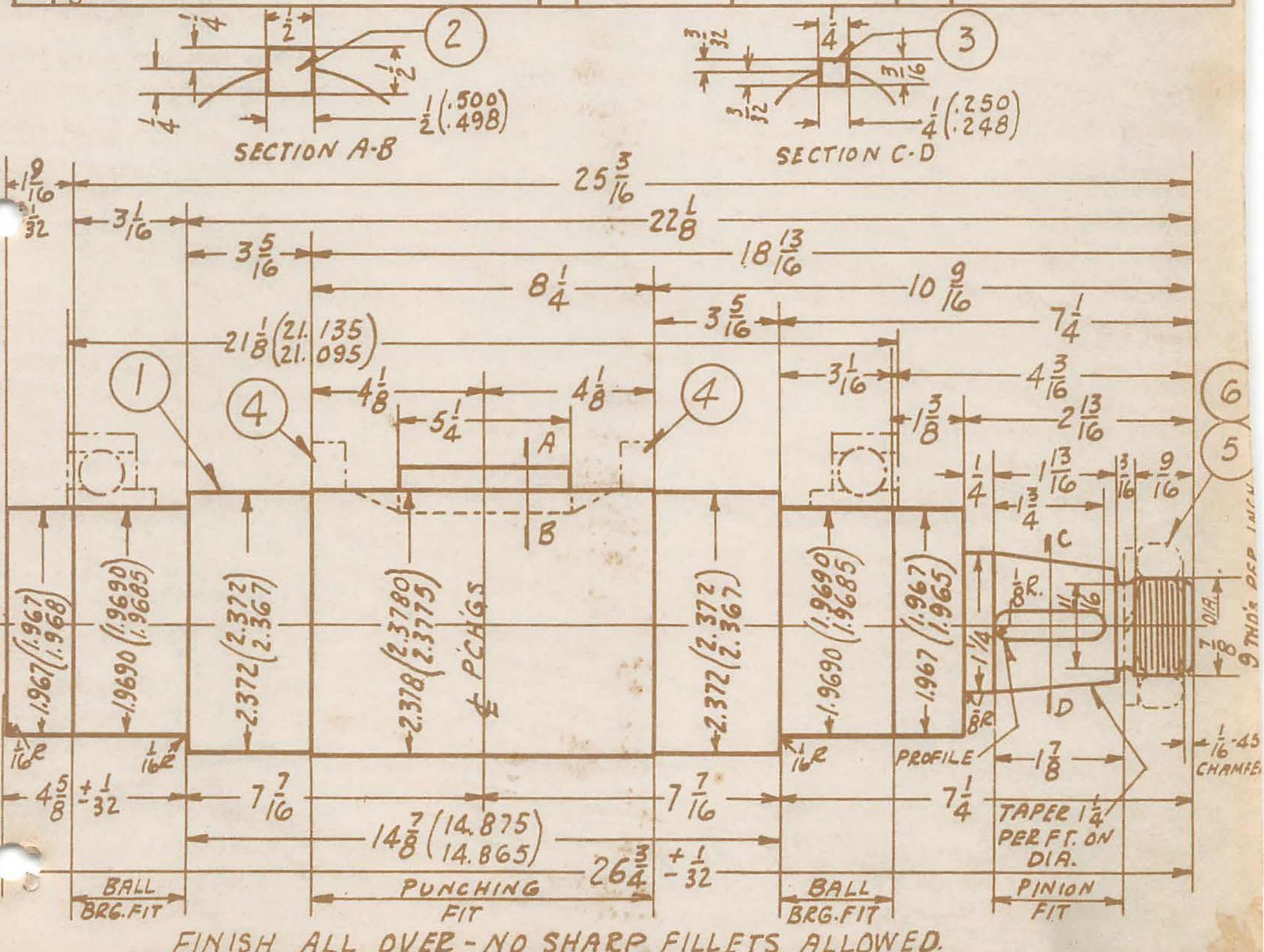
ENG. DEPT.—FORM 7343 G

WESTINGHOUSE ELECTRIC & MFG. CO.. EAST PITTSBURGH. PA.. U. S. A.
MOTOR A.C. FRAME #365 TYPE "CS" SPECIAL

DIMENSIONS IN INCHES — SHAFT — SCALE N.T.S

DWG. 49-D-320 SUB. 1 — BILL OF MATERIAL — FINISH CHART 10028

Item	Description-Material-Ref. Dwg.	FIN. CHART LINE NO.	Style No.	Pat. No.	Req.	Tool Record Space. No. in ◯ = Item No.
1	SHAFT FROM 26 3/4 OF 2 1/2 DIA. S.BAR #1422					
	EST. ROUGH WT. = 37.18# FIN. WT. = 25.75#				1	
2	KEY		266470		1	
3	KEY FROM 1 3/4 OF 3/16 x 1/4 C.R.S. #2084				1	
4	RING		822625		2	
5	7/8 LOCK WASHER				1	
6	7/8 LOCK NUT				1	



FINISH ALL OVER - NO SHARP FILLETS ALLOWED.

Tool Reference Dwg. No. — 49-D-320

Dates	12/21/34	12/21/34		12/21/34

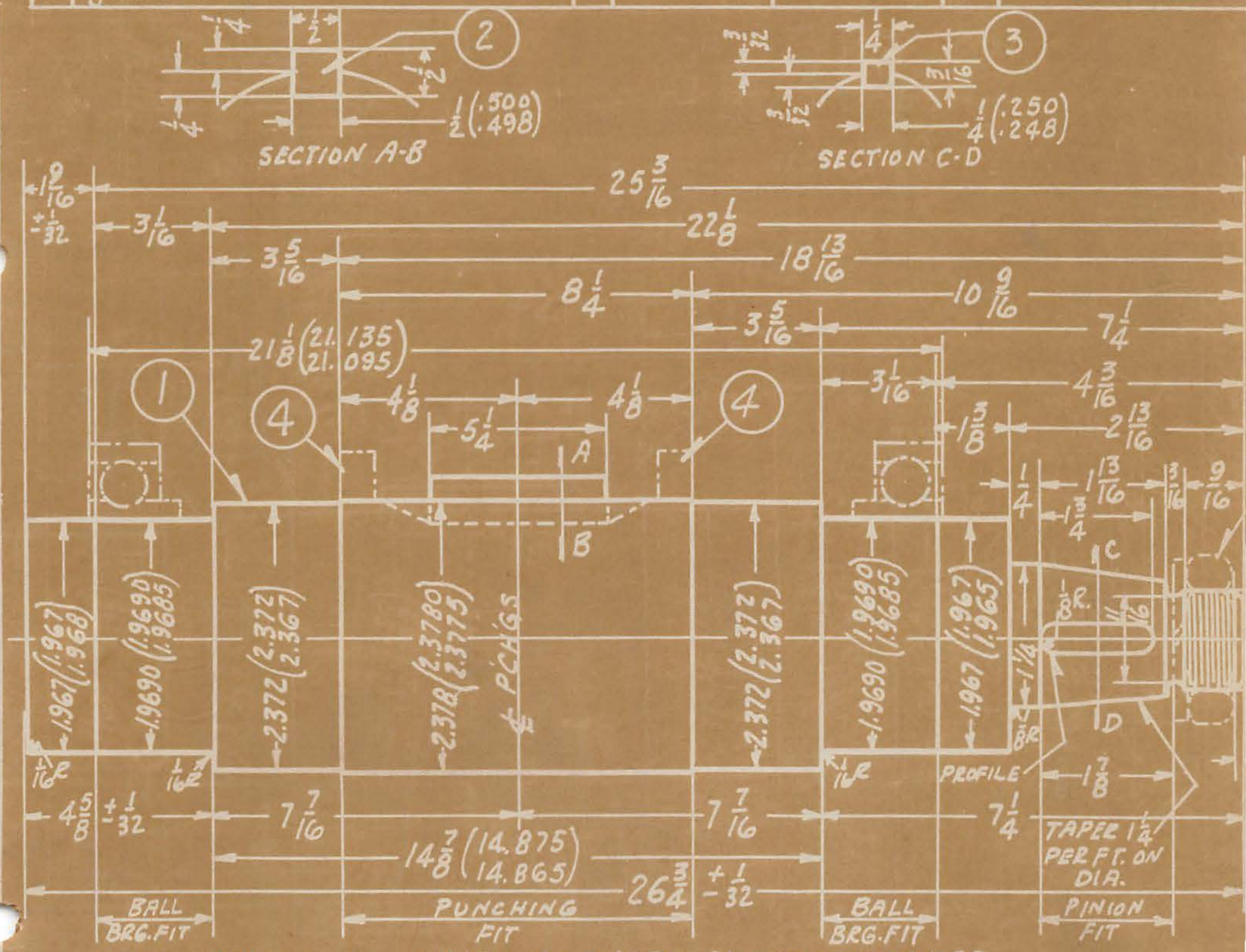
WESTINGHOUSE ELECTRIC & MFG. CO.. EAST PITTSBURGH. PA.. U. S. A.

MOTOR A.C. FRAME #365 TYPE "CS" SPECIAL

DIMENSIONS IN INCHES SHAFT SCALE N.T.S

DWG. 49-D-320 SUB. 1 BILL OF MATERIAL FINISH CHART 10028

Item	Description-Material-Ref. Dwg.	FIN. CHART LINE NO.	Style No.	Pat. No.	Req.	Tool Record Space. No. in ◯ = Item No.
1	SHAFT FROM 26¾ OF 2½ DIA. S. BAR #1422					
	EST. ROUGH WT. = 37.18# FIN. WT. = 25.75#				1	
2	KEY		266470		1	
3	KEY FROM 1¾ OF 3/16 X ¼ C.R.S. #2084				1	
4	RING		B22625		2	
5	7/8 LOCK WASHER				1	
6	7/8 LOCK NUT				1	



FINISH ALL OVER - NO SHARP FILLETS ALLOWED.

Tool Reference Dwg. No. 49-D-320

G. DEPT.—FORM 7343 G

Dates 12/21/34 12/21/34 12/21/34

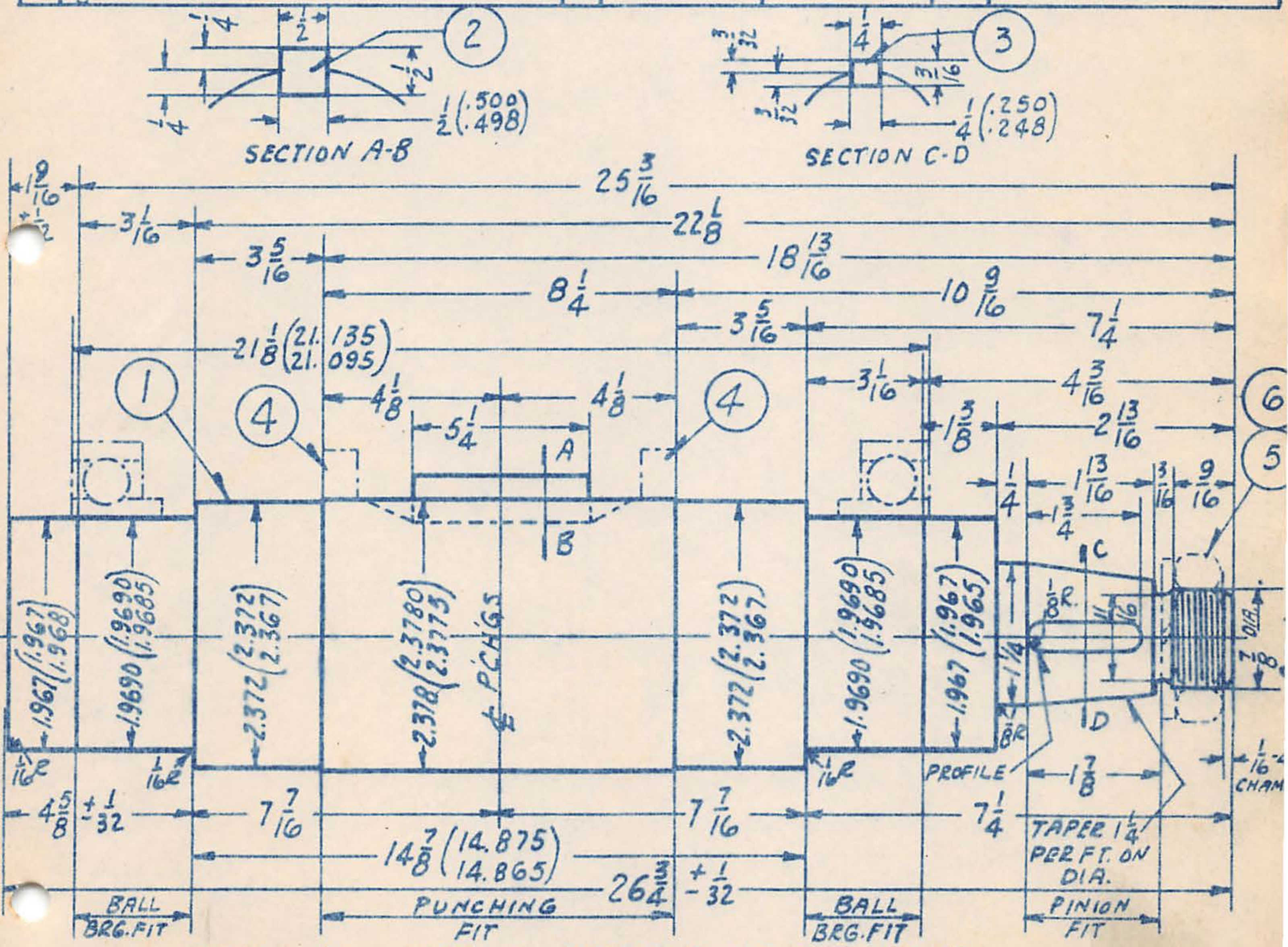
WESTINGHOUSE ELECTRIC & MFG. CO. EAST PITTSBURGH. PA.. U. S. A.

MOTOR A.C. FRAME #365 TYPE "CS" SPECIAL

DIMENSIONS IN INCHES SHAFT **SCALE** N.T.S

DWG. 49-D-320 **SUB.** 1 **BILL OF MATERIAL** FINISH CHART 10028

Item	Description-Material-Ref. Dwg.	Fin. Chart Line No.	Style No.	Pat. No.	Req.	Tool Record Space. No. in ◯ = Item No.
1	SHAFT FROM 26¾ OF 2½ DIA. S.BAR #1422					
	EST. ROUGH WT. = 37.18# FIN. WT. = 25.75#				1	
2	KEY		266470		1	
3	KEY FROM 1¾ OF 3/16 x ¼ C.R.S. #2084				1	
4	RING		822625		2	
5	⅞ LOCK WASHER				1	
6	⅞ LOCK NUT				1	



FINISH ALL OVER - NO SHARP FILLETS ALLOWED.

Tool Reference Dwg. No. 49-D-320

Dates 12/21/34 12/21/34 12/21/34

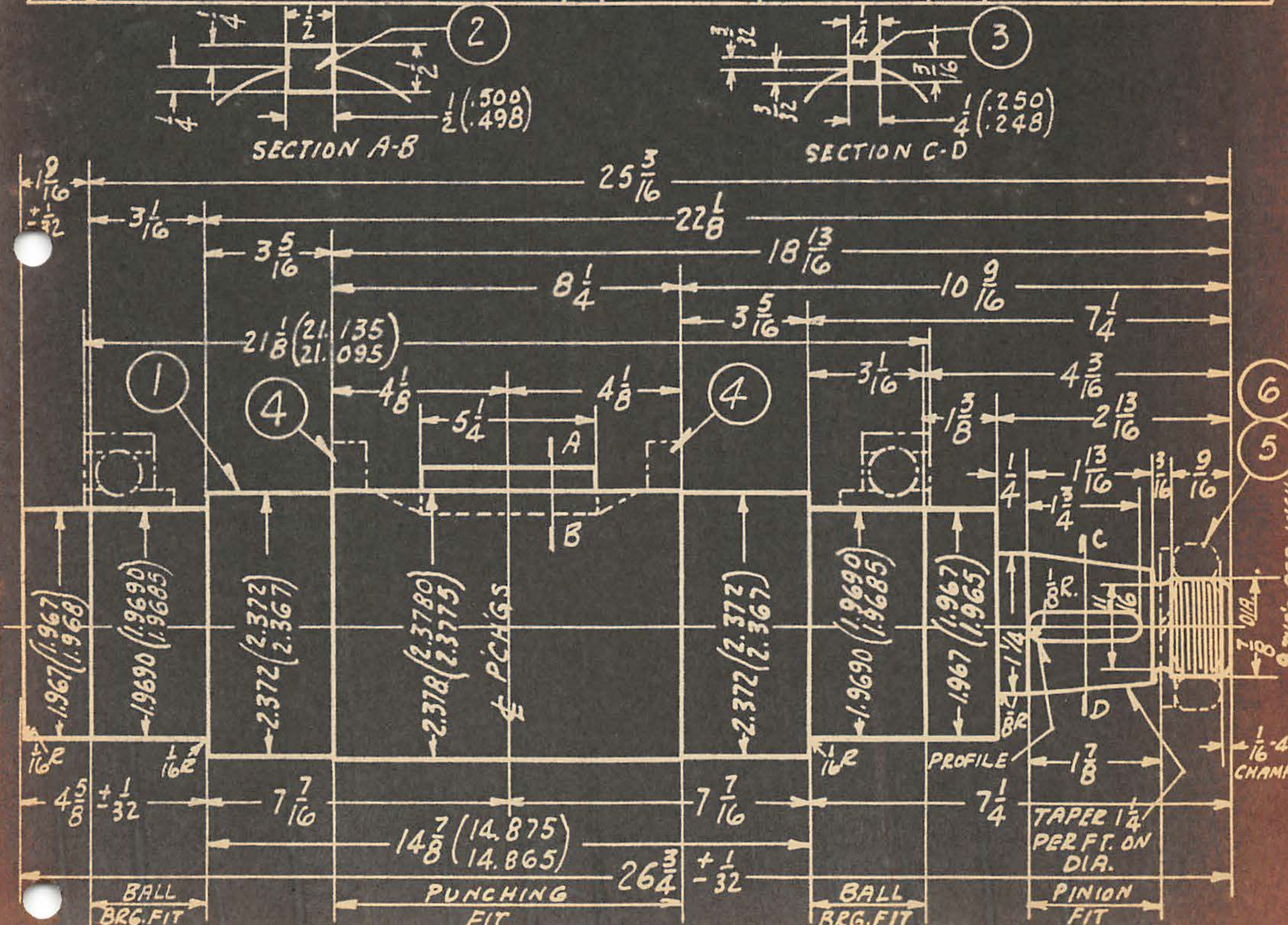
WESTINGHOUSE ELECTRIC & MFG. CO., **EAST PITTSBURGH, PA., U. S. A.**

MOTOR A.C. FRAME #365 TYPE "CS" SPECIAL

DIMENSIONS IN INCHES SHAFT **SCALE** N.T.S

DWG. 49-D-320 **SUB.** 1 **BILL OF MATERIAL** **FINISH CHART** 10028

Item	Description-Material-Ref. Dwg.	Fin. Chart Line No.	Style No.	Pat. No.	Req.	Tool Record Space. No. in ○ = Item No.
1	SHAFT FROM 26¾ OF 2½ DIA. S.BAR #1422					
	EST. ROUGH WT. = 37.18# FIN. WT. = 25.75#				1	
2	KEY		266470		1	
3	KEY FROM 1¾ OF 3/16 × ¼ C.R.S. #2084				1	
4	RING		822625		2	
5	7/8 LOCK WASHER				1	
6	7/8 LOCK NUT				1	



FINISH ALL OVER - NO SHARP FILLETS ALLOWED.

Tool Reference Dwg. No. 49-D-320

Dates 12/21/34 12/21/34 12/21/34

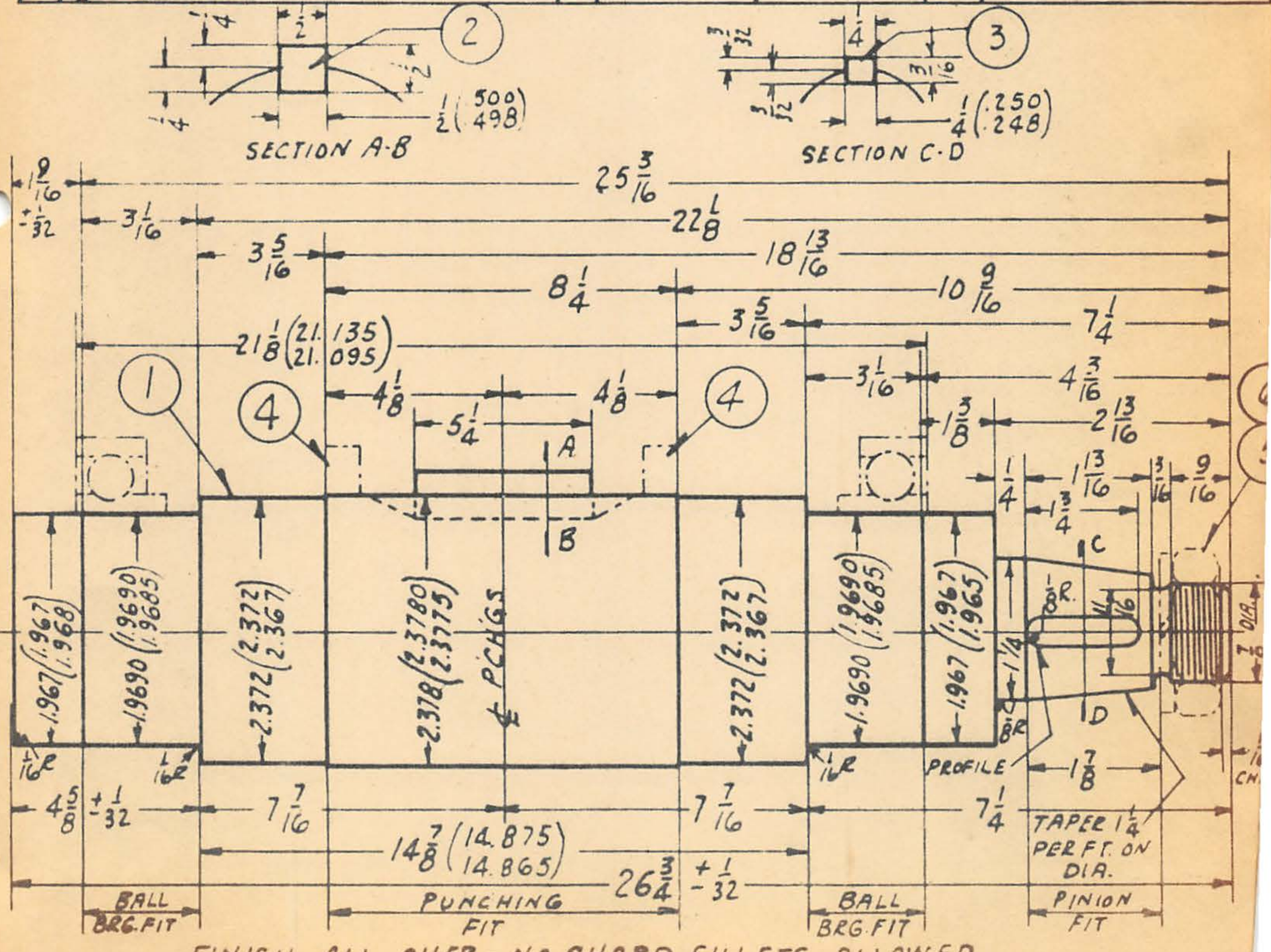
WESTINGHOUSE ELECTRIC & MFG. CO.. EAST PITTSBURGH. PA.. U. S. A.

MOTOR A.C. FRAME #365 TYPE "CS" SPECIAL

DIMENSIONS IN INCHES SHAFT SCALE N.T.S

DWG. 49-D-320 SUB. 1 BILL OF MATERIAL FINISH CHART 10028

Item	Description-Material-Ref. Dwg.	FIN. CHART LINE NO.	Style No.	Pat. No.	Req.	Tool Record Space. No. in ◯ = Item No.
1	SHAFT FROM 26 3/4 OF 2 1/2 DIA. S.BAR #1422					
	EST. ROUGH WT.: 37.18# FIN WT = 25.75#				1	
2	KEY		266470		1	
3	KEY FROM 1 3/4 OF 3/16 x 1/4 C.R.S. #2084				1	
4	RING		822625		2	
5	7/8 LOCK WASHER				1	
6	7/8 LOCK NUT				1	



FINISH ALL OVER - NO SHARP FILLETS ALLOWED.

Tool Reference Dwg. No. 49-D-320

Dates 12/21/34 12/21/34 12/21/34

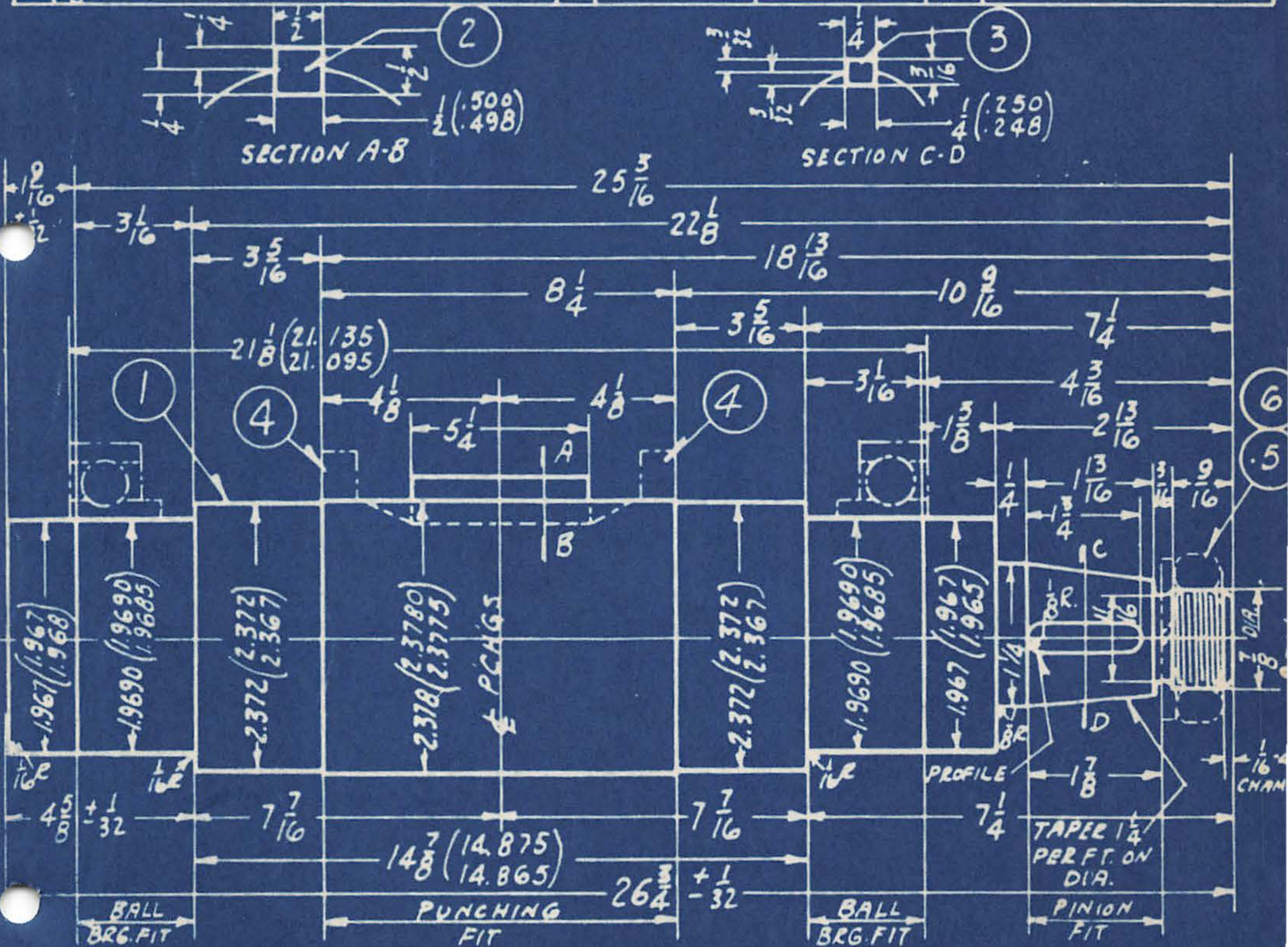
WESTINGHOUSE ELECTRIC & MFG. CO., EAST PITTSBURGH, PA., U. S. A.

MOTOR A.C. FRAME #365 TYPE "CS" SPECIAL

DIMENSIONS IN INCHES SHAFT SCALE N.T.S

DWG. 49-D-320 SUB. 1 BILL OF MATERIAL FINISH CHART 10028

Item	Description-Material-Ref. Dwg.	Fin. Chart Line No.	Style No.	Pat. No.	Req.	Tool Record Space. No. in ◯ = Item No.
1	SHAFT FROM 26¾ OF 2½ DIA. S.BAR #1422					
	EST. ROUGH WT.=37.18# FIN. WT.=25.75#				1	
2	KEY		266470		1	
3	KEY FROM 1¾ OF 3/16 x ¼ C.R.S. #2084				1	
4	RING		822625		2	
5	7/8 LOCK WASHER				1	
6	7/8 LOCK NUT				1	



FINISH ALL OVER - NO SHARP FILLETS ALLOWED.

Tool Reference Dwg. No. 49-D-320

S.	D.	Dft.	Approvals
1	Dates	12/21/34	12/21/34	12/21/34

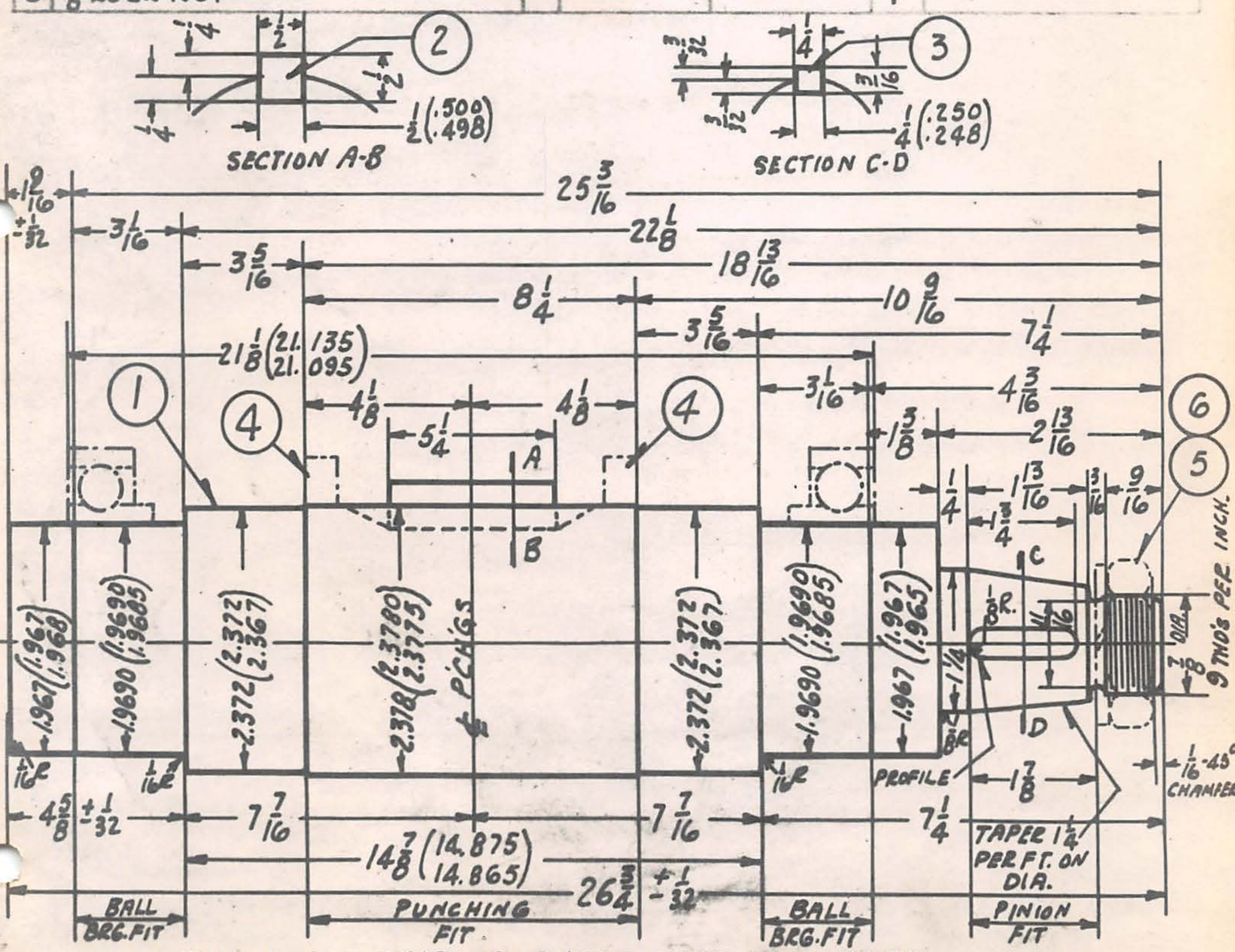
WESTINGHOUSE ELECTRIC & MFG. CO.. EAST PITTSBURGH PA. U. S. A.

MOTOR A.C. FRAME # 365 TYPE "CS" SPECIAL

DIMENSIONS IN INCHES SHAFT SCALE N.T.S

DWG. 49-D-320 SUB. 1 BILL OF MATERIAL FINISH CHART 10028

Item	Description-Material-Ref. Dwg.	Fin. Chart Line No	Style No.	Pat. No.	Req.	Tool Record Space
1	SHAFT FROM 26¾ OF 2½ DIA. S.BAR #1422					
	EST. ROUGH WT. = 37.18# FIN. WT. = 25.75#				1	
2	KEY		266470		1	
3	KEY FROM 1¾ OF 3/16 x ¼ C.R.S. #2084				1	
4	RING		B22625		2	
5	7/8 LOCK WASHER				1	
6	7/8 LOCK NUT				1	



FINISH ALL OVER - NO SHARP FILLETS ALLOWED.

Tool Reference Dwg. No. 49-D-320

1	Dates	12/21/34	12/21/34		12/21/34

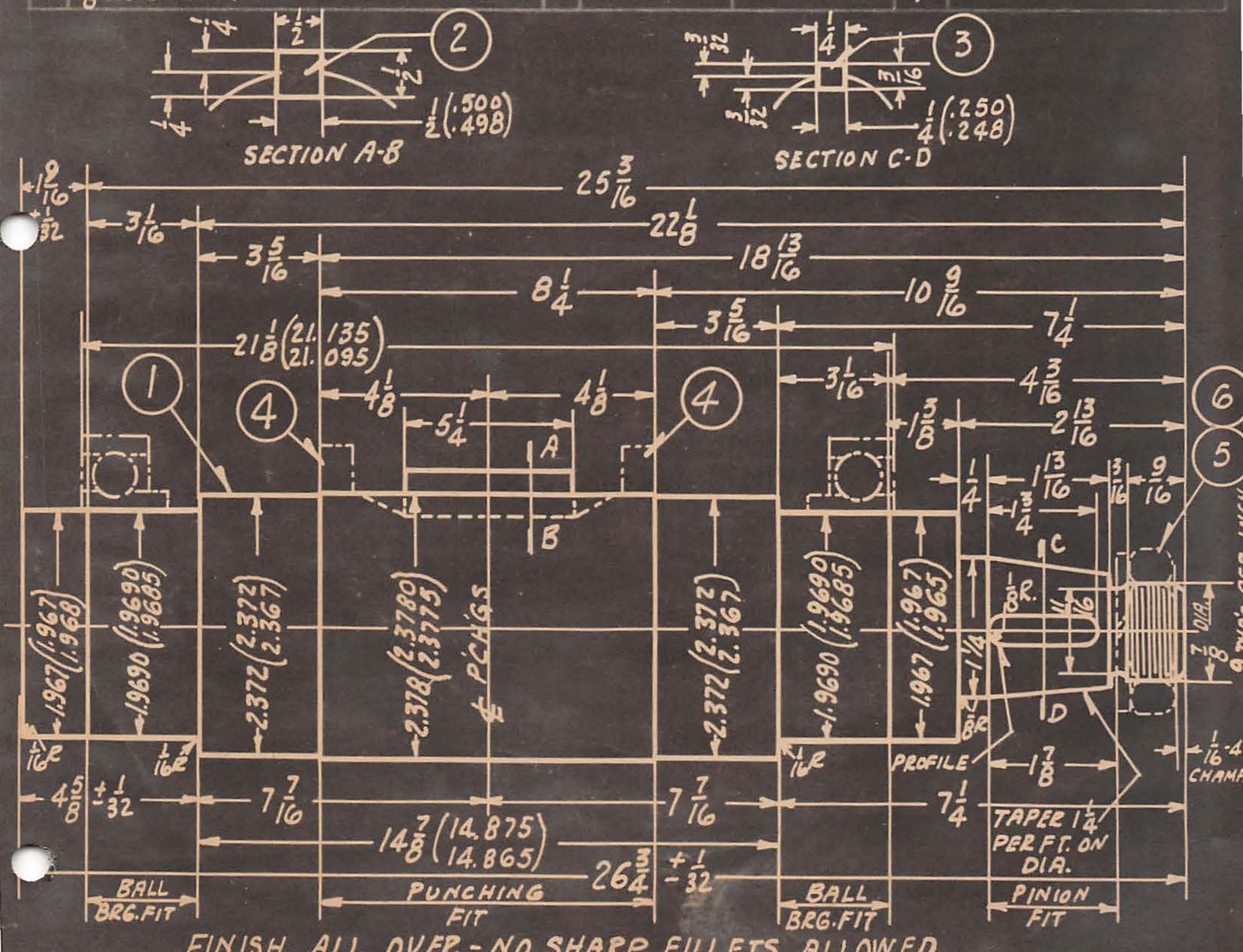
WESTINGHOUSE ELECTRIC & MFG. CO., EAST PITTSBURGH, PA., U. S. A.

MOTOR A.C. FRAME #365 TYPE "CS" SPECIAL

DIMENSIONS IN INCHES SHAFT SCALE N.T.S

DWG. 49-D-320 SUB. 1 BILL OF MATERIAL FINISH CHART 10028

Item	Description-Material-Ref. Dwg.	Fin. Chart Line No.	Style No.	Pat. No.	Req.	Tool Record Space. No. in ◯ = Item No.
1	SHAFT FROM 26¾ OF 2½ DIA. S.BAR #1422					
	EST. ROUGH WT. = 37.18# FIN. WT. = 25.75#				1	
2	KEY		266470		1	
3	KEY FROM 1¾ OF 3/16 x ¼ C.R.S. #2084				1	
4	RING		822625		2	
5	7/8 LOCK WASHER				1	
6	7/8 LOCK NUT				1	



FINISH ALL OVER - NO SHARP FILLETS ALLOWED.

Tool Reference Dwg. No. 49-D-320